TITLE IV
WASTEWATER TREATMENT AND DISPOSAL

CHAPTER 60
SCOPE OF TITLE—DEFINITIONS—FORMS—RULES OF PRACTICE
[Prior to 7/1/83, see DEQ Chs 15 and 24]
[Prior to 12/3/86, Water, Air and Waste Management[900]]

567—60.1(455B,17A) Scope of title. The department has jurisdiction over the surface and groundwater of the state to prevent, abate and control water pollution, by establishing standards for water quality and for direct or indirect discharges of wastewater to waters of the state and by regulating potential sources of water pollution through a system of general rules or specific permits. The construction and operation of any wastewater disposal system and the discharge of any pollutant to a water of the state requires a specific permit from the department, unless exempted by the department.

This chapter provides general definitions applicable in this title and rules of practice, including forms, applicable to the public in the department's administration of the subject matter of this title.

Chapter 61 contains the water quality standards of the state, including classification of surface waters. Chapter 62 contains the standards or methods for establishing standards relevant to the discharge of pollutants to waters of the state. Chapter 63 identifies monitoring, analytical and reporting requirements pertaining to permits for the operation of wastewater disposal systems. Chapter 64 contains the standards and procedures for obtaining construction, operation and discharge permits for wastewater disposal systems other than those associated with animal-feeding operations. Chapter 65 specifies minimum waste control requirements and permit requirements for animal-feeding operations. Chapter 66 specifies restrictions on pesticide application to waters. Chapter 68 contains standards and licensing requirements applicable to commercial septic tank cleaners. Chapter 69 specifies guidelines for private sewage disposal.

567—60.2(455B) Definitions. The following definitions apply to this title, unless otherwise specified in the particular chapter of this title:

"Act" means the Federal Water Pollution Control Act as amended through July 1, 1999, 33 U.S.C. §1251 et seq.

"Acute toxicity" means that level of pollutants which would rapidly induce a severe and unacceptable impact on organisms.

"Aquatic pesticide" means any pesticide, as defined in Iowa Code section 206.2, that is labeled for application to surface water.

"ASTM" means "Annual Book of Standards, Part 31, Water." The publication is available from the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pennsylvania 19103.

"Best management practice (BMP)" means a practice or combination of practices that is determined, after problem assessment, examination of alternative practices, and appropriate public participation, to be the most effective, practicable (including technological, economic and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.

"Biochemical oxygen demand (five-day)" means the amount of oxygen consumed in the biological processes that break down organic matter in water by aerobic biochemical action in five days at 20°C.

"Carbonaceous biochemical oxygen demand (five-day)" means the amount of oxygen consumed in the biological processes that break down carbonaceous organic matter in water by aerobic biochemical action in five days at 20°C.

"Chronic toxicity" means that level of pollutants which would, over long durations or recurring exposure, cause a continuous, adverse or unacceptable response in organisms.

"Continuing planning process (CPP)" means the continuing planning process, including any revision thereto, required by Sections 208 and 303(e) of the Act (33 U.S.C. §§1288 and 1313(e)) for state water pollution control agencies. The continuing planning process is a time-phased process by which the department, working cooperatively with designated areawide planning agencies:

a. Develops a water quality management decision-making process involving elected officials of state and local units of government and representatives of state and local executive departments that conduct activities related to water quality management.

b. Establishes an intergovernmental process (such as coordinated and cooperative programs with the state conservation commission in aquatic life and recreation matters, and the soil conservation division, department of agriculture and land stewardship in nonpoint pollution control matters) which provides for water quality management decisions to be made on an areawide or local basis and for the incorporation of such decisions into a comprehensive and cohesive statewide program. Through this process, state regulatory programs and activities will be incorporated into the areawide water quality management decision process.

c. Develops a broad-based public participation (such as utilization of such mechanisms as basin advisory committees composed of local elected officials, representatives of areawide planning agencies, the public at large, and conservancy district committees) aimed at both informing and involving the public in the water quality management program.

d. Prepares and implements water quality management plans, which identify water quality goals and established state water quality standards, defines specific programs, priorities and targets for preventing and controlling water pollution in individual approved planning areas and establishes policies which guide decision making over at least a 20-year span of time (in increments of 5 years).

e. Based on the results of the statewide (state and areawide) planning process, develops the state strategy to be updated annually, which sets the state's major objectives, approach, and priorities for preventing and controlling pollution over a five-year period.

f. Translates the state strategy into the annual state program plan (required under Section 106 of the federal Act), which establishes the program objectives, identifies the resources committed for the state program each year, and provides a mechanism for reporting progress toward achievement of program objectives.

g. Periodically reviews and revises water quality standards as required under Section 303(c) of the federal Act.

"CFR" means the Code of Federal Regulations as published by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

"Crossover point" means that location in a river or stream in which the flow shifts from being principally along one bank to the opposite bank. This crossover point usually occurs within two curves or an S-shaped curve of a water course.

"Culture water" means reconstituted water or other acceptable water used for culturing test organisms.

"Deep well" means a well located and constructed in such a manner that there is a continuous layer of low permeability soil or rock at least 5 feet thick located at least 25 feet below the normal ground surface and above the aquifer from which water is to be drawn.

"Diluted effluent sample" means a sample of effluent diluted with culture water at the same ratio as the dry weather design flow to the applicable receiving stream flow contained in the zone of initial dilution as allowed in 567—subrule 61.2(4), regulatory mixing zones, including paragraphs *"b," "c"* and *"d."*

"Dilution ratio" means, for a specific wastewater discharger, the ratio of the seven-day, ten-year low stream flow to the effluent design flow, e.g., a dilution ratio of 2:1 has two parts stream flow to one part effluent flow.

"Dry weather design flow" means the 30-day average flow which a facility is designed to discharge during dry weather conditions.

"Effluent toxicity test" means a test to determine the toxicity of a chemical or chemicals contained in a wastewater discharge on living organisms in a static 48-hour exposure under laboratory conditions.

"EPA methods" means "Methods for Chemical Analysis of Water and Wastes," 1979 U.S. EPA, EPA-600/4-79/020, Environmental Monitoring and Support Laboratory, National Environmental Research Center, Cincinnati, Ohio 45268. This publication is available from the National Technical Information Service, Springfield, Virginia 22151.

"Excessive infiltration/inflow (I/I)" as referred to in the discussion of secondary treatment is the quantity of I/I which is more economical to remove from the sewer system than to transport and treat at a wastewater facility. Within the cost-effectiveness analysis performed to determine excessive I/I, the transportation and treatment costs will be based on the percent removal requirements specified in the appropriate subrule, 567—subrule 62.3(1) or 62.3(3).

"Fecal coliform" means the portion of the coliform group which is present in the gut or the feces of warm-blooded animals. It includes organisms which are capable of producing gas from lactose broth in a suitable culture medium within 24 hours at 44.5 + / - 0.2°C.

"FR" means the Federal Register, published daily by the Office of the Federal Register, National Archives and Record Service, General Services Administration, Washington, D.C. 20408 and distributed by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

"General permit" means an NPDES permit issued to a class of facilities which could be conditioned and described by a single permit. DNR's statutory authority for general permits is restricted to storm water discharges pursuant to Iowa Code section 455B.103A.

"High quality resource waters" means waters designated as such in 567—Chapter 61, of exceptional recreational or ecological significance. These waters are important, unique or sensitive ecologically but whose chemical quality may not be particularly good as measured by traditional standards of Chapter 61, or whose resource potential is based on the existing physical or biological integrity rather than on existing chemical integrity.

"High quality waters" means those waters designated as such in 567—Chapter 61, which exceed the levels described in Chapter 61 as necessary to protect existing water uses. The chemical integrity of these waters is enhanced and distinguished as high quality by the exceptional water clarity necessary to protect and maintain the existing designated uses of those waters. Examples include the cold water streams designated by the Iowa conservation commission as Iowa's catchable and special trout streams, and the Iowa Great Lakes chain.

"Human health criteria" means that level of pollution which, in the case of noncarcinogens, prevents adverse health effects in humans, and in the case of carcinogens, represents a level of incremental cancer risk of 1 in 100,000. The numerical criteria are based on the human consumption of an average of 6.5 grams of fish and shellfish per day by a 70-kilogram individual for a life span of 70 years.

"Intermittent watercourses" means watercourses which contain flow associated with rainfall/runoff events and which periodically go dry even in pooled areas.

"Local public works department" means a city or county public works department, a board of trustees of a city utility organized pursuant to Iowa Code chapter 388, or a sanitary sewer district organized pursuant to Iowa Code chapter 358.

"Losing streams" means streams which lose 30 percent or more of their flow during the seven-day, ten-year low stream flow periods to cracks and crevices of rock formations, sand and gravel deposits, or sinkholes in the streambed.

"Low permeability" means a soil layer of well-sorted, fine grain-sized sediments or of rock that under normal hydrostatic pressures would not be significantly permeable. Low permeability soils may include homogeneous clays below the zone of weathering, mudstone, claystone, shale, and some glacial till.

"Major" means for municipalities, a facility having a discharge flow or wet weather design flow of 1.0 mgd or greater. For industries it means a facility which is designated by EPA as being a major industry based on the EPA point rating system which uses pounds of wastes discharged for each facility.

"Major contributing industry" means an industrial user of a treatment works that:

a. Has a flow of 50,000 gallons or more per average workday;

b. Has a flow greater than 5 percent of the flow carried by the treatment works receiving the waste;

c. Has in its waste a toxic pollutant in toxic amounts as defined in standards issued under Section 307(a) of the Act and adopted by reference in 567—62.5(455B); or

d. Is found by the department in connection with the issuance of an NPDES permit to have a significant impact, either singly or in combination with other contributing industries, on that treatment works or upon the quality of effluent from that treatment works.

"Milligrams per liter (mg/l)" means milligrams of solute per liter of solution (equivalent to parts per million-assuming unit density). A microgram (ug) is 1/1000 of a milligram.

"Minimum flow" means that established stream flow in lieu of the seven-day, ten-year low stream flow to which the provisions of 567—Chapter 61 apply.

"Minor" means all remaining municipal and industrial facilities which have wastewater discharge flows and which are not designated as major facilities.

"Mixing zone" means a delineated portion of a stream or river in which wastewater discharges will be allowed to combine and disperse into the water body. The chronic criteria of 567—subrule 61.3(3) will apply at the boundary of this zone.

"Mortality" means, for the purpose of the 48-hour acute toxicity test, death, immobilization, or serious incapacitation of the test organisms.

"Navigable water" means a water of the United States.

"Nephelometric" means the nephelometric method of determining turbidity as stated in Standard Methods, pp. 132-134.

"Nonpoint source" means a source of pollutants that is not a point source.

"NPDES permit" means an operation permit, issued after the department has obtained approval of its National Pollutant Discharge Elimination System (NPDES) program from the administrator, that authorizes the discharge of any pollutant into a navigable water.

"Pathogen" means any microorganism or virus that can cause disease.

"Pesticide" shall have the definition as stated in Iowa Code section 206.2.

"pH" means the hydrogen ion activity of a solution expressed as the logarithm of the reciprocal of the hydrogen ion activity in moles per liter at 25°C. pH is a measure of the relative acidity or alkalinity of the solution. The range extends from 0 to 14; 7 being neutral, 0 to 7 being acidic, and 7 to 14 being alkaline.

"Positive toxicity test result" means a statistical significant difference of mortality rate between the control and the diluted effluent test.

"POTW" or *"publicly owned treatment works"* means any device or system used in the treatment of municipal sewage or industrial wastes of a liquid nature which is owned by a municipal corporation or other public body created by or under Iowa law and having jurisdiction over disposal of sewage, industrial wastes or other wastes, or a designated and approved management agency under Section 208 of the Act.

"Primary contact" means any recreational or other water use in which there is direct human contact with the water involving considerable risk of ingestion of water or contact with sensitive body organs such as the eyes, ears and nose, in quantities sufficient to pose a significant health hazard.

"Records of operation" means department of natural resources report forms or such other report forms, letters or documents which may be acceptable to the department that are designed to indicate specific physical, chemical, or biological values for wastewater during a stated period of time.

"Regional administrator" means the regional administrator of the United States Environmental Protection Agency, Region VII, 726 Minnesota Avenue, Kansas City, Kansas 66101.

"Secondary contact" means any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating and any limited contact incidental to shoreline activity. This would include users who do not swim or float in the water body while on a boating activity.

"Seven-day average" means the arithmetic mean of pollutant parameter values for samples collected in a period of seven consecutive days.

"Seven-day, ten-year low streamflow" means the lowest average stream flow which would statistically occur for seven consecutive days once every ten years.

"Shallow well" means a well located and constructed in such manner that there is not a continuous 5-foot layer of low permeability soil or rock between the aquifer from which the water supply is drawn and a point 25 feet below the normal ground surface.

"Significantly more stringent limitation" relates to secondary treatment $CBOD_5$ and SS limitations necessary to meet the percent removal requirements of at least 5 mg/l more stringent than the otherwise applicable concentration-based limitations (i.e., less than 20 mg/l in the case of $CBOD_5$), or the percent removal limitations in 567—subrules 62.3(1) and 62.3(3), if such limits would, by themselves, force significant construction or other significant capital expenditure.

"Sinkhole" means any depression caused by the dissolution or collapse of subterranean materials in a carbonate formation or in gypsum or rock salt deposits through which water may be drained or lost to the local groundwater system. Such depressions may or may not be open to the surface at times. Intermittently, sinkholes may hold water forming a pond.

"Standard methods" means "Standard Methods for the Examination of Water and Wastewater," 15th Edition. This publication is available from the American Public Health Association, 1015 15th Street N.W., Washington, D.C. 20005.

"Storm water" means storm water runoff, snow melt runoff and surface runoff and drainage. (NOTE: Agricultural storm water runoff is excluded by federal regulation 40 CFR 122.3(e) as amended through June 15, 1992.)

"Storm water discharge associated with industrial activity" means the discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. The term does not include discharges from facilities or activities excluded from the NPDES program under 40 CFR Part 122 as amended through June 15, 1992. For the categories of industries identified in paragraphs "1" to "10" of this definition, the term includes, but is not limited to, storm water discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process wastewaters (as defined at 40 CFR 401 amended through June 15, 1992); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water.

For the categories of industries identified in paragraph "11," the term includes only storm water discharges from all the areas (except access roads and rail lines) that are listed in the previous sentence where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are exposed to storm water. For the purposes of this paragraph, material handling activities include the: storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, finished product, by-product or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the drainage from the excluded areas is not mixed with storm water drained from the above described areas. Industrial facilities (including industrial facilities that are federally, state, or municipally owned or operated that meet the description of the facilities listed in paragraphs "1" to "11" of this definition include those facilities designated under 40 CFR 122.26(a)(1)(v) as amended through June 15, 1992. The following categories of facilities are considered to be engaging in "industrial activity" for purposes of this definition:

1. Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR Subchapter N as amended through June 15, 1992 (except facilities with toxic pollutant effluent standards which are exempted under paragraph "11" of this definition);

2. Facilities classified as Standard Industrial Classifications 24 (except 2434), 26 (except 265 and 267), 28 (except 283 and 285), 29, 311, 32 (except 323), 33, 3441, 373;

3. Facilities classified as Standard Industrial Classifications 10 through 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations meeting the definition of a reclamation area under 40 CFR 434.11(1) as amended through June 15, 1992) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable state or federal reclamation requirements after December 17, 1990, and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with, or that has come into contact with, any overburden, raw material, intermediate products, finished products, by-products or waste products located on the site of such operations; (inactive mining operations are mining sites that are not being actively mined, but which have an identifiable owner/operator; inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities are undertaken for the sole purpose of maintaining a mining claim);

4. Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under Subtitle C of RCRA;

5. Landfills, land application sites, and open dumps that have received any industrial wastes (waste that is received from any of the facilities described under this definition) including those that are subject to regulation under Subtitle D of RCRA;

6. Facilities involved in the recycling of materials, including metal scrap yards, battery reclaimers, salvage yards, and automobile junkyards, including, but not limited to, those classified as Standard Industrial Classifications 5015 and 5093;

7. Steam electric power generating facilities, including coal handling sites;

8. Transportation facilities classified as Standard Industrial Classifications 40, 41, 42 (except 4221-4225), 43, 44, 45 and 5171 which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, airport deicing operations, or which are otherwise identified under paragraphs "1" to "7" or "9" or "11" of this definition are associated with industrial activity;

9. Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system used in the storage, treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 mgd or more, or required to have an approved pretreatment program under 40 CFR 403 (as amended through June 15, 1992). Not included are farmlands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with 40 CFR 503 (as amended through June 15, 1992);

10. Construction activity including clearing, grading and excavation activities except operations that result in the disturbances of less than 5 acres of total land area which are not part of a larger common plan of development or sale;

11. Facilities under Standard Industrial Classifications 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221-4225 (and which are not otherwise included within paragraphs "2" to "10").

"Storm water point sources" means point sources that serve to collect, channel, direct, and convey storm water and which are subject to Section 402(p) of the federal Clean Water Act and Parts 122, 123, and 124 of Title 40 of the Code of Federal Regulations (as amended through June 15, 1992).

"Temperature" means a measure of the heat content of water.

"Thirty-day average" means the arithmetic mean of pollutant parameter values of samples collected in a period of 30 consecutive days.

"Toxicity reduction evaluation (TRE) program" means a step-wise process, similar to that found in EPA Document/600/2-88/062, which combines effluent toxicity tests and analysis of the chemical characteristics of the effluent to determine the cause of the effluent toxicity or the treatment methods which will reduce the effluent toxicity, or both.

"Turbidity" is a measure of the optical property of the particles of mud, clay, silt, finely divided organic matter, or microscopic organisms suspended in water that interfere with light transmission, causing the light to be scattered and absorbed rather than transmitted through the water in straight lines.

"Uncontrolled sanitary landfill" means a landfill or open dump, whether in operation or closed, that does not meet the requirements for runon or runoff controls established pursuant to subtitle D of the Solid Waste Disposal Act.

"Valid effluent toxicity test" means the mortality in the control test is not greater than 10 percent and all test conditions contained in 567—subrule 63.4(2)*"b"* "Standard Operating Procedure: Effluent Toxicity Testing, Iowa Department of Natural Resources" are met.

"Water contact recreational canoeing" means the type of activities associated with canoeing outings in which primary contact with the water does occur. This would include users who swim or float in the water body while on a canoeing outing.

"Zone of initial dilution" means a delineated portion of a mixing zone in which wastewater discharges will be allowed to rapidly combine and begin dispersing into the water body. The acute criteria of 567—subrule 61.3(3) will apply at the boundary of this zone.

567—60.3(455B,17A) Forms. The following forms are used by the public to apply for departmental approvals and to report on activities related to the wastewater programs of the department. All forms may be obtained from the Environmental Protection Division, Administrative Support Station, Iowa Department of Natural Resources, Henry A. Wallace Building, 900 East Grand Avenue, Des Moines, Iowa 50319-0032. Properly completed application forms should be submitted in accordance with the instructions, to the Wastewater Permits Section, Environmental Protection Division. Reporting forms should be submitted to the appropriate field office. (See rule 567—1.4(455B))

60.3(1) *Construction permit application forms.*

a. Schedules 28 — "A" to "S"
"A" — General Information 542-3129
"B" — Collection System 542-3095
"C" — Lateral Sewer System 542-3096
"D" — Trunk and Interceptor Sewer 542-3097
"E" — Pump Station 542-3098
"F" — Treatment Project Site Selection 542-3099
"G" — Treatment Project Design Data 542-3106
"H1" — Schematic Flow Diagram 542-3101
"H2" — Treatment Process Removal Efficiency 542-3102
"H3" — Mechanical Plant Reliability 542-3239
"I" — Screening, Grit Removal and Flow Measurement 542-3089
"J" — Septic Tank System 542-3090
"K1" — Controlled Discharge Pond 542-3091
"K2" — Aerated Pond 542-3092
"K3" — Anaerobic Lagoon 542-3093
"L" — Settling Tanks 542-3094
"M" — Fixed Film Reactor—Stationary Media 542-3081
"N" — Rotating Biological Contactor 542-3082
"O" — Aeration Tanks or Basins 542-3083
"P" — Gas Chlorination 542-3084
"Q" — Sludge Dewatering and Disposal 542-3085
"R1" — Sludge Dewatering and Disposal 542-3086
"R2A" — Low Rate Land Application of Sludge (Part I) 542-3087
"R2B" — Low Rate Land Application of Sludge (Part II) 542-3088
"S" — Land Application of Wastewater (To be developed)

b. Form 29 — Sewage Treatment Agreement 542-3219

60.3(2) *Operation permit application forms.*

a. Form 30 — public or private domestic sewerage systems 542-3220

b. Form 31 — treatment agreement 542-3221

c. Form 34 — open feedlots 542-3225

d. Form 1 — general information for industrial, manufacturing or commercial systems 542-1376. (For storm water discharge EPA Form 3510-1, also referred to as EPA Form 1, may be used.)

e. Form 2 — facilities which do not discharge process wastewater—industrial, manufacturing or commercial systems 542-1377. (For storm water discharge EPA Form 3510-2E, also referred to as EPA Form 2E, may be used.)

f. Form 3 — facilities which discharge process wastewater existing sources—industrial, manufacturing, and commercial systems 542-1378. (For storm water discharge EPA Form 3510-2C, also referred to as EPA Form 2C, may be used.)

g. Form 4 — facilities which discharge process wastewater—new sources—industrial, manufacturing or commercial systems 542-1379. (For storm water discharge EPA Form 3510-2D, also referred to as EPA Form 2D, may be used.)

h. EPA Form 2F (EPA Form 3510-2F)—application for NPDES individual permit to discharge storm water discharge associated with industrial activity.

i. Notice of Intent for Coverage Under Storm Water NPDES General Permit No. 1 "Storm Water Discharge Associated with Industrial Activity" or General Permit No. 2 "Storm Water Discharge Associated with Industrial Activity for Construction Activities" 542-1415.

j. Notice of intent for coverage under NPDES General Permit No. 4 "Discharge from On-Site Wastewater Treatment and Disposal Systems."

60.3(3) *Wastewater monitoring report forms.*

a. Form 35-1 — general/monthly 542-3226

b. Form 35-2 — general/quarterly 542-3227

c. Form 35-3 — commercial/industrial contributor/monthly 542-3228

d. Form 35-4 — general/monthly 542-3229

e. Form 35-5 — waste stabilization lagoons 542-3230

f. Form 35-6 — trickling filter 542-3231

g. Form 35-7 — activated sludge/contact stabilization 542-3232

h. Form 35-8 — commercial/industrial contributor/quarterly 542-3233

567—60.4(455B,17A) Application procedures and requirements generally. The following procedures and requirements pertain to applications for wastewater permits. More specific and substantive requirements may be found in 567—Chapters 61 to 65.

60.4(1) *Construction permit applications.*

a. *General.* All applications for a construction permit pursuant to 567—64.2(455B) shall be made in accordance with the instructions for completion of application for wastewater construction permit. The instructions specify the requirements for federal grant and nongrant projects. In addition to the required engineering documents and data the appropriate application schedules (Form 28, "A" to "S") and Sewage Treatment Agreement Form 29 as applicable shall be submitted. The applicant will be promptly notified if the application is incomplete or improperly filled out, and an application will not be reviewed until such time as a complete and proper submission is made. A wastewater construction permit will be denied when the application does not meet all requirements for issuance of a construction permit. For a system with permits conditioned by limitations on additional loads under 567—subrule 64.2(10), paragraphs *"a," "b"* or *"f,"* subsequent construction permit applications must be accompanied by an accounting of connections and additional loading since the time the initial conditioned permit was issued.

b. Sewer systems. If Schedule B, "Collection System," of the construction permit application does not provide sufficient information on which to make a determination to grant or deny a sewer system construction permit under this subrule, additional information, such as the following, may be requested and evaluated:

(1) Sources of extraneous flows,
(2) Population trends and density in area to be served,
(3) Quality and strength of wastes from industrial contributors,
(4) Existing water used data,
(5) Historical and experience data,
(6) Location, capacity, and condition of existing sewer system and stormwater drainage courses,
(7) Probability of annexation or development of adjacent areas,
(8) Service agreements with adjacent communities,
(9) Existence and effectiveness of industrial waste ordinance,
(10) Drainage area limits,
(11) Bypasses and combined sewers,
(12) Municipal sewer map.

c. Site surveys. For new or expanded wastewater treatment facilities, an application for a site survey must be submitted, by the applicant's engineer, generally in advance of a full application for construction permit. The applicant should allow 60 days from the date of application for preliminary approvals. The following minimum information must be submitted:

(1) A preliminary engineering report or a cover letter which contains a brief description of the proposed treatment process and assurance that the project is in conformance with the long-range planning of the area.
(2) Completed Schedule A — General Information
(3) Completed Schedule F — Treatment Project Site Selection
(4) Completed Schedule G — Treatment Project Design Data

If the application is incomplete it will be returned to the engineer for completion. When the application is complete it will be reviewed and if the data submitted indicates on its face that the site would be unsuitable for its intended purpose, a letter of rejection will be sent to the applicant and the engineer. Clarifications and additional data may be requested of the applicant and the engineer. When the application is complete and indicates on its face that the site may be suitable, a site survey will be conducted by department staff.

d. Modification. Persons seeking a modification to plans and specifications after having been issued a construction permit shall submit an addendum to plans and specifications, a change order, or revised plans and specifications, along with the reasons for the proposed changes, to the department. A supplemental written permit or approval will be issued when the changes submitted by the applicant meet department requirements. Construction shall not proceed until such changes have been approved.

60.4(2) *Operation permits applications.*

a. General. A person desiring to obtain or renew a wastewater operation permit or an Iowa NPDES permit pursuant to 64 or 65 must complete the appropriate application form as identified in 60.3(2). The application shall be reviewed when it is complete, and if approvable the department shall prepare and issue the permit or proposed permit, as applicable, and transmit it to the applicant. A permit or renewal will be denied when the applicant does not meet one or more requirements for issuance or renewal of such permit.

b. *Amendments.* A permittee seeking an amendment to its operation permit shall make a written request to the department which shall include the nature of the requested amendment and the reasons therefor. A variance or amendment to the terms and conditions of a general permit shall not be granted. If a variance or amendment to a general permit is desired, the applicant must apply for an individual permit following the procedures in 567—paragraph 64.3(4)*"a."*

(1) Schedules of compliance. Requests to amend a permit schedule of compliance shall be made at least 30 days prior to the next scheduled compliance date which the permittee contends it is unable to meet. The request shall include any proposed changes in the existing schedule of compliance, and any supporting documentation for the time extension. An extension may be granted by the department for cause. Cause includes unusually adverse weather conditions, equipment shortages, labor strikes, federal grant regulation requirements, or any other extenuating circumstances beyond the control of the requesting party. Cause does not include economic hardship, profit reduction, or failure to proceed in a timely manner.

(2) Interim effluent limitations. A request to amend interim effluent limitations in an existing permit shall include the proposed amendments to existing effluent limitations and any documentation in support of the proposed limitations. The department will evaluate the request based upon the capability of the disposal system to meet interim effluent limitations, taking into account the contributions to treatment capability which can be made by good operation and maintenance of the disposal system and by minor alterations which can be made to the system to improve its capability. The department may deny a request where the inability of the disposal system to meet interim effluent limitations is due to increased waste loadings on the system over those loadings upon which the interim limitations were based.

(3) Monitoring requirements. A request for a change in monitoring requirements in an existing permit shall include the proposed changes in monitoring requirements and documentation therefor. The requesting permittee must provide monitoring results which are frequent enough to reflect variations in actual wastewater characteristics over a period of time and are consistent in results from sample to sample. The department will evaluate the request based upon whether or not less frequent sample results accurately reflect actual wastewater characteristics and whether operational control can be maintained.

Upon receipt of a request the department may grant, modify, or deny the request. If the request is denied, the department may notify the permittee of any violation of its permit and may proceed administratively on the violation or may request that the commission refer the matter to the attorney general for legal action.

These rules are intended to implement Iowa Code section 17A.3(1)*"b"* and chapter 455B, division III, part 1.

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CHAPTER 61
WATER QUALITY STANDARDS
[Prior to 7/1/83, DEQ Ch 16]
[Prior to 12/3/86, Water, Air and Waste Management[900]]

567—61.1 Rescinded, effective August 31, 1977.

567—61.2(455B) General considerations.

61.2(1) *Policy statement.* It shall be the policy of the commission to protect and enhance the quality of all the waters of the state. In the furtherance of this policy it will attempt to prevent and abate the pollution of all waters to the fullest extent possible consistent with statutory and technological limitations. This policy shall apply to all point and nonpoint sources of pollution.

These water quality standards establish selected criteria for certain present and future designated uses of the surface waters of the state. The standards establish the areas where these uses are to be protected and provide minimum criteria for waterways having nondesignated uses as well. Many surface waters are designated for more than one use. In these cases the more stringent criteria shall govern for each parameter.

Certain of the criteria are in narrative form without numeric limitations. In applying such narrative standards, decisions will be based on the U.S. Environmental Protection Agency's methodology described in "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses," (1985) and on the rationale contained in "Quality Criteria for Water," published by the U.S. Environmental Protection Agency (1977), as updated by supplemental Section 304 (of the Act) Ambient Water Quality Criteria documents. To provide human health criteria for parameters not having numerical values listed in 61.3(3) Table 1, the required criteria will be based on the rationale contained in these EPA criteria documents. The human health criterion considered will be the value associated with the consumption of fish flesh and a risk factor of 10^{-5} for carcinogenic parameters. For noncarcinogenic parameters, the recommended EPA criterion will be selected. For Class C water, the EPA criteria for fish and water consumption will be selected using the same considerations for carcinogenic and noncarcinogenic parameters as noted above.

All methods of sample collection, preservation, and analysis used in applying any of the rules in these standards shall be in accord with those prescribed in 567—Chapter 63.

61.2(2) *Antidegradation policy.* It is the policy of the state of Iowa that:

a. Existing surface water uses and the level of water quality necessary to protect the existing uses will be maintained and protected.

b. Chemical integrity: For those water bodies where water quality significantly exceeds levels necessary to protect existing uses and the waters designated as high quality in 61.3(5)*"e,"* that water quality will be maintained at or above existing quality, except when it is determined by the environmental protection commission after public hearing and after intergovernmental coordination and public participation provisions noted in the continuing planning process that there is need to allow a lower chemical quality because of necessary and justifiable economic and social development in the area. The state shall ensure adequate chemical quality to fully protect existing uses.

(1) Bear Creek, mouth in Winneshiek County and tributary to the Upper Iowa River.

(2) Bloody Run, mouth in Clayton County and tributary to the Mississippi River.

(3) Catfish Creek from Swiss Valley Park in Dubuque County to its source.

(4) Unnamed Creek known locally as Coldwater Creek with mouth in Winneshiek County and tributary to the Upper Iowa River.

(5) Fenchel Creek, mouth to Richmond Springs, in Delaware County and tributary to the Maquoketa River.

(6) Odell Branch (aka Fountain Spring Creek), mouth (section 10, T90N, R4W, Delaware County), tributary to Elk Creek, which is tributary to the Turkey River to west line of section 9, T90N, R4W, Delaware County.

(7) Iowa Great Lakes chain of lakes in Dickinson County, including West Lake Okoboji, Spirit Lake, East Lake Okoboji, Minnewashta Lake, Upper Gar Lake, and Lower Gar Lake.

(8) North Bear Creek, with mouth in Winneshiek County and tributary to Bear Creek, listed as number 1 in this listing.

(9) North Cedar Creek, with mouth in Clayton County and tributary to Sny Magill Creek.

(10) Sny Magill Creek, with mouth in Clayton County and tributary to the Mississippi River.

(11) Turkey River, from the point where it is joined by the Volga River in Clayton County to Vernon Springs in Howard County.

(12) Waterloo Creek, with mouth in Allamakee County and tributary to the Upper Iowa River.

(13) Maquoketa River, from confluence with South Fork Maquoketa River (section 16, T90N, R6W, Delaware County) to Highway 3 (north line of section 24, T91N, R7W, Fayette County).

(14) Spring Branch, mouth (section 10, T88N, R5W, Delaware County) to spring source (section 35, T89N, R5W, Delaware County).

(15) Little Turkey River, Clayton-Delaware County line to south line of section 11, T90N, R3W, Delaware County.

(16) Middle Fork Little Maquoketa River (aka Bankston Creek), west line of section 31, T90N, R1E to north line of section 33, T90N, R1W, Dubuque County.

(17) Brush Creek, north line of section 23, T85N, R3E to north line of section 1, T85N, R3E, Jackson County.

(18) Dalton Lake — Jackson County.

(19) Little Mill Creek, mouth (Jackson County) to west line of section 29, T86N, R4E, Jackson County.

(20) Mill Creek (aka Big Mill Creek), from confluence with Little Mill Creek in section 13, T86N, R4E, Jackson County, to confluence with Unnamed Creek, section 1, T86N, R3E, Jackson County.

(21) Unnamed Creek (tributary to Mill Creek), mouth (section 1, T86N, R3E, Jackson County) to west line of section 1, T86N, R3E, Jackson County.

(22) Unnamed Creek (aka South Fork Big Mill), tributary to Mill Creek, from mouth (section 8, T86N, R4E, Jackson County) to west line of section 17, T86N, R4E, Jackson County.

(23) Clear Creek, mouth (Allamakee County) to west line of section 25, T99N, R4W, Allamakee County.

(24) French Creek, mouth (Allamakee County) to east line of section 23, T99N, R5W, Allamakee County.

(25) Hickory Creek, mouth (Allamakee County) to south line of section 28, T96N, R5W, Allamakee County.

(26) Little Paint Creek, mouth to north line of section 30, T97N, R3W, Allamakee County.

(27) Paint Creek, from confluence with Little Paint Creek to road crossing in section 18, T97N, R4W, Allamakee County.

(28) Patterson Creek, mouth (Allamakee County) to east line of section 3, T98N, R6W, Allamakee County.

(29) Silver Creek, mouth (Allamakee County) to south line of section 31, T99N, R5W, Allamakee County.

(30) Village Creek, mouth (Allamakee County) to west line of section 19, T98N, R4W, Allamakee County.

(31) Wexford Creek, mouth to west line of section 25, T98N, R3W, Allamakee County.

(32) Buck Creek, mouth (Clayton County) to west line of section 9, T93N, R3W, Clayton County.

(33) Ensign Creek (aka Ensign Hollow), mouth (section 28, T92N, R6W, Clayton County) to spring source (section 29, T92N, R6W, Clayton County).

(34) South Cedar Creek (aka Cedar Creek), mouth (Clayton County) to north line of section 7, T92N, R3W, Clayton County.

(35) Bear Creek, mouth (Fayette County) to west line of section 6, T92N, R7W, Fayette County.

(36) Unnamed Creek (aka Glover's Creek), mouth to west line of section 15, T94N, R8W, Fayette County.

(37) Grannis Creek, mouth to west line of section 36, T93N, R8W, Fayette County.

(38) Mink Creek, mouth to west line of section 15, T93N, R7W, Fayette County.

(39) Otter Creek, mouth (Fayette County) to confluence with Unnamed Creek (aka Glover's Creek) in section 22, T94N, R8W, Fayette County.

(40) Nichols Creek (aka Bigalk Creek), mouth (section 18, T100N, R10W, Winneshiek County) to west line of section 23, T100N, R11W, Howard County.

(41) Spring Creek, mouth (Mitchell County) to north line of section 8, T97N, R16W, Mitchell County.

(42) Turtle Creek, mouth (Mitchell County) to east line of section 7, T99N, R17W, Mitchell County.

(43) Wapsipinicon River, from the town of McIntire to north line of section 20, T99N, R15W, Mitchell County.

(44) Bohemian Creek, mouth (Winneshiek County) to Howard County Road 58 (west line of section 2, T97N, R11W, Howard County).

(45) Coon Creek, mouth (Winneshiek County) to road crossing in section 13, T98N, R7W, Winneshiek County.

(46) Smith Creek (aka Trout River), mouth to south line of section 33, T98N, R7W, Winneshiek County.

(47) Unnamed Stream (aka Trout Run), mouth to south line of section 27, T98N, R8W, Winneshiek County.

(48) Twin Springs Creek, mouth to springs in Twin Springs Park in section 20, T98N, R8W, Winneshiek County.

(49) Canoe Creek (aka West Canoe Creek), from Winneshiek County Road W38 to west line of section 8, T99N, R8W, Winneshiek County.

c. Standards and restrictions more stringent than those applied to other waters may be applied by the commission to those waters listed below when it is determined that such more stringent standards and restrictions are necessary to fully maintain water quality at existing levels.

West Lake Okoboji in Dickinson County.

d. The Mississippi River and the Missouri River do not meet the criteria of 61.2(2)*"c"* but nevertheless constitute waters of exceptional state and national significance. Water quality management decisions will be made in consideration of the exceptional value of the resource.

e. In furtherance of the policy stated in 61.2(2)*"b,"* there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources, and feasible management and regulatory programs pursuant to Section 208 of the Federal Water Pollution Control Act for nonpoint sources, both existing and proposed.

f. Physical and biological integrity: The waters designated as high-quality resource waters in 61.3(5)*"e"* will receive protection of existing uses through maintaining water quality levels necessary to fully protect existing uses or improve water quality to levels necessary to meet the designated use criterion in Tables 1, 2 and 3 and at preserving or enhancing the physical and biological integrity of these waters. This involves the protection of such features of the water body as channel alignment, bed characteristics, water velocity, aquatic habitat, and the type, distribution and abundance of existing aquatic species.

g. It is the intent of the antidegradation policy to protect and maintain the existing physical, biological, and chemical integrity of all waters of the state. Consistency with Iowa's water quality standards requires that any proposed activity modifying the existing physical, biological, or chemical integrity of a water of the state shall not adversely impact these resource attributes, either on an individual or cumulative basis. An adverse impact shall refer to the loss of or irreparable damage to the aquatic, semiaquatic or wildlife habitat or population, or a modification to the water body that would cause an overall degradation to the aquatic or wildlife population and diversity. The fish and wildlife division of the department and the U.S. Fish and Wildlife Service shall serve as consultants to the department for assessing impacts. Exceptions to the preceding will be allowed only if full mitigation is provided by the applicant and approved by the department.

For those waters of the state designated as high quality or high quality resource waters and the Mississippi and Missouri Rivers, any proposed activity that will adversely impact the existing physical, chemical, or biological integrity of that water will not be consistent with Iowa's water quality standards. Mitigation will not be allowed except in highly unusual situations where no other project alternatives exist. In these cases, full mitigation must be provided by the applicant and approved by the department.

h. This policy shall be applied in conjunction with water quality certification review pursuant to Section 401 of the Act. In the event that activities are specifically exempted from flood plain development permits or any other permits issued by this department in 567—Chapters 70, 71, and 72, the activity will be considered consistent with this policy. Other activities not otherwise exempted will be subject to 567—Chapters 70, 71, and 72 and this policy. The repair and maintenance of a drainage district ditch as defined in 567—70.2(455B,481A) will not be considered a violation of the antidegradation policy for the purpose of implementing Title IV of these rules. United States Army Corps of Engineers (Corps) nationwide permits 3, 4, 5, 6, 7, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 29, 30, 31, 32, 33, 34, 36, 37, 38, and 40, as promulgated December 13, 1996, are certified pursuant to Section 401 of the Clean Water Act. Regional permit numbers 2, 7, 12, and 20 of the Rock Island District of the Corps are also certified. No specific Corps permit or 401 certification is required for activities covered by these permits unless required by the nationwide permit or the Corps, and the activities are allowed subject to the terms of the nationwide and regional permits.

61.2(3) *Minimum treatment required.* All wastes discharged to the waters of the state must be of such quality that the discharge will not cause the narrative or numeric criteria limitations to be exceeded. Where the receiving waters provide sufficient assimilative capacity that the water quality standards are not the limiting factor, all point source wastes shall receive treatment in compliance with minimum effluent standards as adopted in rules by the department.

There are numerous parameters of water quality associated with nonpoint source runoff which are of significance to the designated water uses specified in the general and specific designations in 61.3(455B), but which are not delineated. It shall be the intent of these standards that the limits on such nonpoint source related parameters when adopted shall be those that can be achieved by best management practices as defined in the course of the continuing planning process from time to time. Existing water quality and nonpoint source runoff control technology will be evaluated in the course of the Iowa continuing planning process, and best management practices and limitations on specific water quality parameters will be reviewed and revised from time to time to ensure that the designated water uses and water quality enhancement goals are met.

61.2(4) *Regulatory mixing zones.* Mixing zones are recognized as being necessary for the initial assimilation of point source discharges which have received the required degree of treatment or control. Mixing zones shall not be used for, or considered as, a substitute for minimum treatment technology required by subrule 61.2(3). The objective of establishing mixing zones is to provide a means of control over the placement and emission of point source discharges so as to minimize environmental impacts. Waters within a mixing zone shall meet the general water quality criteria of subrule 61.3(2). Waters at and beyond mixing zone boundaries shall meet all applicable standards and the chronic and human health criteria of subrule 61.3(3), Tables 1 and 3, for that particular water body or segment. A zone of initial dilution may be established within the mixing zone beyond which the applicable standards and the acute criteria of subrule 61.3(3) will be met. For waters designated under subrule 61.3(5), any parameter not included in Tables 1, 2 and 3 of subrule 61.3(3), the chronic and human health criteria, and the acute criterion calculated following subrule 61.2(1), will be met at the mixing zone and zone of initial dilution boundaries, respectively.

a. Due to extreme variations in wastewater and receiving water characteristics, spatial dimensions of mixing zones shall be defined on a site-specific basis. These rules are not intended to define each individual mixing zone, but will set maximum limits which will satisfy most biological, chemical, physical and radiological considerations in defining a particular mixing zone. Additional details are noted in the "Supporting Document for Iowa Water Quality Management Plans," Chapter IV, July 1976, as revised on March 20, 1990, for considering unusual site-specific features such as side channels and sand bars which may influence a mixing zone. Applications for operation permits under 567—subrule 64.3(1) may be required to provide specific information related to the mixing zone characteristics below their outfall so that mixing zone boundaries can be determined.

b. For parameters included in Table 1 only (which does not include ammonia nitrogen), the dimensions of the mixing zone and the zone of initial dilution will be calculated using a mathematical model presented in the "Supporting Document for Iowa Water Quality Management Plans," Chapter IV, July 1976, as revised on March 20, 1990, or from instream studies of the mixing characteristics during low flow. In addition, the most restrictive of the following factors will be met:

(1) The stream flow in the mixing zone may not exceed the most restrictive of the following:

1. Twenty-five percent of the seven-day, ten-year low stream flow for interior streams and rivers, and the Big Sioux and Des Moines Rivers.

2. Ten percent of the seven-day, ten-year low stream flow for the Mississippi and Missouri Rivers.

3. The stream flow contained in the mixing zone at the most restrictive of the applicable mixing zone length criteria, noted below.

(2) The length of the mixing zone below the point of discharge shall be set by the most restrictive of the following:

1. The distance to the juncture of two perennial streams.

2. The distance to a public water supply intake.

3. The distance to the upstream limits of an established recreational area, such as public beaches, and state, county and local parks.

4. The distance to the middle of a crossover point in a stream where the main current flows from one bank across to the opposite bank.

5. The distance to another mixing zone.

6. Not to exceed a distance of 2000 feet.

7. The location where the mixing zone contained the percentages of stream flow noted in 61.2(4)"*b*"(1).

(3) The width of the mixing zone is calculated as the portion of the stream containing the allowed mixing zone stream flow. The mixing zone width will be measured perpendicular to the basic direction of stream flow at the downstream boundary of the mixing zone. This measurement will only consider the distance of continuous water surface.

(4) The width and length of the zone of initial dilution may not exceed 10 percent of the width and length of the mixing zone.

c. The stream flow used in determining wasteload allocations to ensure compliance with the chronic and human health criteria of Table 1 will be that value contained at the boundary of the allowed mixing zone. This stream flow may not exceed the following percentages of the seven-day, ten-year low stream flow as measured at the point of discharge:

(1) Twenty-five percent for interior streams and rivers, and the Big Sioux and Des Moines Rivers.

(2) Ten percent for the Mississippi and Missouri Rivers.

The stream flow in the zone of initial dilution used in determining effluent limits to ensure compliance with the acute criteria of Table 1 may not exceed 10 percent of the calculated flow associated with the mixing zone.

d. For toxic parameters noted in Table 1, the following exceptions apply to the mixing zone requirements:

(1) No mixing zone or zone of initial dilution will be allowed for waters designated as lakes or wetlands.

(2) No zone of initial dilution will be allowed in waters designated as cold water.

(3) The use of a diffuser device to promote rapid mixing of an effluent in a receiving stream will be considered on a case-by-case basis with its usage as a means for dischargers to comply with an acute numerical criterion.

(4) A discharger to interior streams and rivers, the Big Sioux and Des Moines Rivers, and the Mississippi or Missouri Rivers may provide to the department, for consideration, instream data which

technically supports the allowance of an increased percentage of the stream flow contained in the mixing zone due to rapid and complete mixing. Any allowed increase in mixing zone flow would still be governed by the mixing zone length restrictions. The submission of data should follow the guidance provided in the "Supporting Document for Iowa Water Quality Management Plans" (Iowa Department of Water, Air and Waste Management, Chapter IV, July 1976, as revised on March 20, 1990).

e. For ammonia criteria noted in Table 3, the dimensions of the mixing zone and the zone of initial dilution will be calculated using a mathematical model presented in the "Supporting Document for Iowa Water Quality Management Plans," Chapter IV, July 1976, as revised on March 20, 1990, or from instream studies of the mixing characteristics during low flow. In addition, the most restrictive of the following factors will be met:

(1) The stream flow in the mixing zone may not exceed the most restrictive of the following:

1. One hundred percent of the seven-day, ten-year low stream flow for locations where the dilution ratio is less than or equal to 2:1.

2. Fifty percent of the seven-day, ten-year low stream flow for locations where the dilution ratio is greater than 2:1, but less than or equal to 5:1.

3. Twenty-five percent of the seven-day, ten-year low stream flow for locations where the dilution ratio is greater than 5:1.

4. The stream flow contained in the mixing zone at the most restrictive of the applicable mixing zone length criteria, noted below.

(2) The length of the mixing zone below the point of discharge shall be set by the most restrictive of the following:

1. The distance to the juncture of two perennial streams.
2. The distance to a public water supply intake.
3. The distance to the upstream limits of an established recreational area, such as public beaches, and state, county, and local parks.
4. The distance to the middle of a crossover point in a stream where the main current flows from one bank across to the opposite bank.
5. The distance to another mixing zone.
6. Not to exceed a distance of 2000 feet.
7. The location where the mixing zone contained the percentages of stream flow noted in 61.2(4)"*e*"(1).

(3) The width of the mixing zone is calculated as the portion of the stream containing the allowed mixing zone stream flow. The mixing zone width will be measured perpendicular to the basic direction of stream flow at the downstream boundary of the mixing zone. This measurement will only consider the distance of continuous water surface.

(4) The width and length of the zone of initial dilution may not exceed 10 percent of the width and length of the mixing zone.

f. For ammonia criteria noted in Table 3, the stream flow used in determining wasteload allocations to ensure compliance with the chronic criteria of Table 3 will be that value contained at the boundary of the allowed mixing zone. This stream flow may not exceed the percentages of the seven-day, ten-year low stream flow noted in 61.2(4)"*e*"(1) as measured at the point of discharge.

The pH and temperature values at the boundary of the mixing zone used to select the chronic ammonia criteria of Table 3 will be from one of the following sources. The source of the pH and temperature data will follow the sequence listed below, if applicable data exists from the source.

(1) Specific pH and temperature data provided by the applicant gathered at their mixing zone boundary. Procedures for obtaining this data are noted in the "Supporting Document for Iowa Water Quality Management Plans," Chapter IV, July 1976, as revised on March 20, 1990.

(2) Regional background pH and temperature data provided by the applicant gathered along the receiving stream and representative of the background conditions at the outfall. Procedures for obtaining this data are noted in the "Supporting Document for Iowa Water Quality Management Plans," Chapter IV, July 1976, as revised on March 20, 1990.

(3) The statewide average background values presented in Table IV-5 of the "Supporting Document for Iowa Water Quality Management Plans," Chapter IV, July 1976, as revised on March 20, 1990.

The stream flow in the zone of initial dilution used in determining effluent limits to ensure compliance with the acute criteria of Table 3 may not exceed 5 percent of the calculated flow associated with the mixing zone for facilities with a dilution ratio of less than or equal to 2:1, and not exceed 10 percent of the calculated flow associated with the mixing zone for facilities with a dilution ratio of greater than 2:1. The pH and temperature values at the boundary of the zone of initial dilution used to select the acute ammonia criteria of Table 3 will be from one of the following sources and follow the sequence listed below, if applicable data exists from the source.

1. Specific effluent pH and temperature data if the dilution ratio is less than or equal to 2:1.

2. If the dilution ratio is greater than 2:1, the logarithmic average pH of the effluent and the regional or statewide pH provided in 61.2(4)*"f"* will be used. In addition, the flow proportioned average temperature of the effluent and the regional or statewide temperature provided in 61.2(4)*"f"* will be used. The procedures for calculating these data are noted in the "Supporting Document for Iowa Water Quality Management Plans," Chapter IV, July 1976, as revised on March 20, 1990.

g. For ammonia criteria noted in Table 3, the following exceptions apply to the mixing zone requirements.

(1) No mixing zone or zone of initial dilution will be allowed for waters designated as lakes or wetlands.

(2) No zone of initial dilution will be allowed in waters designated as cold water.

(3) The use of a diffuser device to promote rapid mixing of an effluent in a receiving stream will be considered on a case-by-case basis with its usage as a means for dischargers to comply with an acute numerical criterion.

(4) A discharger to interior streams and rivers, the Big Sioux and Des Moines Rivers, and the Mississippi and Missouri Rivers may provide to the department, for consideration, instream data which technically supports the allowance of an increased percentage of the stream flow contained in the mixing zone due to rapid and complete mixing. Any allowed increase in mixing zone flow would still be governed by the mixing zone length restrictions. The submission of data should follow the guidance provided in the "Supporting Document for Iowa Water Quality Management Plans" (Iowa Department of Water, Air and Waste Management, Chapter IV, July 1976, as revised on March 20, 1990).

h. Temperature changes within mixing zones established for heat dissipation will not exceed the temperature criteria in 61.3(3)*"b"*(5).

i. The appropriateness of establishing a mixing zone where a substance discharged is bioaccumulative, persistent, carcinogenic, mutagenic, or teratogenic will be carefully evaluated. In such cases, effects such as potential groundwater contamination, sediment deposition, fish attraction, bioaccumulation in aquatic life, bioconcentration in the food chain, and known or predicted safe exposure levels shall be considered.

61.2(5) *Implementation strategy.* Numerical criteria specified in these water quality standards shall be met when the flow of the receiving stream equals or exceeds the seven-day, ten-year low flow. Exceptions may be made for intermittent or low flow streams classified as significant resource warm waters or limited resource warm waters. For these waters, the department may waive the seven-day, ten-year low flow requirement and establish a minimum flow in lieu thereof. Such waiver shall be granted only when it has been determined that the aquatic resources of the receiving waters are of no significance at flows less than the established minimum, and that the continued maintenance of the beneficial uses of the receiving waters will be ensured. In no event will toxic conditions be allowed to occur in the receiving waters outside of mixing zones established pursuant to subrule 61.2(4). The policy for granting waivers is described in the "Supporting Document for Iowa Water Quality Management Plans" (Iowa Department of Water, Air and Waste Management, Chapter IV, July 1976, as revised on March 20, 1990). (Copies are available upon request to the Department of Natural Resources, Henry A. Wallace Building, 900 East Grand, Des Moines, Iowa 50319-0034. Copy also on file with the Iowa Administrative Rules Coordinator.)

All minimum flows established under the provisions of this rule will be published by the department. The minimum flows, commonly termed protected flows, are presented in "Iowa Water Quality Standards: Protected Flows For Selected Stream Segments," dated April 1, 1996. A copy of this document is available upon request from the department. A copy is also on file with the Iowa Administrative Rules Coordinator.

a. The allowable 3°C temperature increase criterion for warm water interior streams, 61.3(3)*"f"*(1), is based in part on the need to protect fish from cold shock due to rapid cessation of heat source and resultant return of the receiving stream temperature to natural background temperature. On low flow streams, in winter, during certain conditions of relatively cold background stream temperature and relatively warm ambient air and groundwater temperature, certain wastewater treatment plants with relatively constant flow and constant temperature discharges will cause temperature increases in the receiving stream greater than allowed in 61.3(3)*"f"*(1).

b. During the period November 1 to March 31, for the purpose of applying the 3°C temperature increase criterion, the minimum protected receiving stream flow rate below such discharges may be increased to not more than three times the rate of flow of the discharge, where there is reasonable assurance that the discharge is of such constant temperature and flow rate and continuous duration as to not constitute a threat of heat cessation and not cause the receiving stream temperature to vary more than 3°C per day.

c. Site-specific water quality criteria may be allowed in lieu of the specific numerical criteria listed in Tables 1 and 3 of this chapter if adequate documentation is provided to show that the proposed criteria will protect all existing or potential uses of the surface water. Site-specific water quality criteria may be appropriate where:

(1) The types of organisms differ significantly from those used in setting the statewide criteria; or

(2) The chemical characteristics of the surface water such as pH, temperature, and hardness differ significantly from the characteristics used in setting the statewide criteria.

Development of site-specific criteria shall include an evaluation of the chemical and biological characteristics of the water resource and an evaluation of the impact of the discharge. All evaluations for site-specific criteria modification must be coordinated through the department, and be conducted using scientifically accepted procedures approved by the department. Any site-specific criterion developed under the provisions of this subrule is subject to the review and approval of the U.S. Environmental Protection Agency. All criteria approved under the provisions of this subrule will be published periodically by the department. Guidelines for establishing site-specific water quality criteria can be found in "Water Quality Standards Handbook," published by the U.S. Environmental Protection Agency, December 1983.

d. A wastewater treatment facility may submit to the department technically valid instream data which provides additional information to be used in the calculations of their wasteload allocations and effluent limitations. This information would be in association with the low flow characteristics, width, length and time of travel associated with the mixing zone or decay rates of various effluent parameters. The wasteload allocation will be calculated considering the applicable data and consistent with the provisions and restrictions in the rules.

567—61.3(455B) Surface water quality criteria.

61.3(1) *Surface water classification.* All waters of the state are classified for protection of beneficial uses. These classified waters include general use segments and designated use segments.

a. *General use segments.* These are intermittent watercourses and those watercourses which typically flow only for short periods of time following precipitation in the immediate locality or as a result of discharges from wastewater treatment facilities, and whose channels are normally above the water table. These waters do not support a viable aquatic community of significance during low flow, and do not maintain pooled conditions during periods of no flow.

However, during periods when sufficient flow exists in the intermittent watercourses to support various uses, the general use segments are to be protected for livestock and wildlife watering, noncontact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses. The aquatic life existing within these watercourses during elevated flows will be protected from acutely toxic conditions.

b. *Designated use segments.* These are water bodies which maintain flow throughout the year, or contain sufficient pooled areas during intermittent flow periods to maintain a viable aquatic community of significance.

Designated use waters are to be protected for all uses of general use segments in addition to the specific uses assigned. Designated use segments include:

(1) Primary contact recreation (Class "A"). Waters in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk of ingesting water in quantities sufficient to pose a health hazard. Such activities would include, but not be limited to, swimming, diving, water skiing, and water contact recreational canoeing.

(2) Cold water aquatic life (Class "B(CW)"). Waters in which the temperature, flow, and other habitat characteristics are suitable for the maintenance of a wide variety of cold water species, including nonreproducing populations of trout and associated aquatic communities.

(3) High quality water (Class "HQ"). Waters with exceptionally better quality than the levels specified in Tables 1, 2 and 3 and with exceptional recreational and ecological importance. Special protection is warranted to maintain the unusual, unique or outstanding physical, chemical, or biological characteristics which these waters possess.

(4) High quality resource water (Class "HQR"). Waters of substantial recreational or ecological significance which possess unusual, outstanding or unique physical, chemical, or biological characteristics which enhance the beneficial uses and warrant special protection.

(5) Significant resource warm water (Class "B(WW)"). Waters in which temperature, flow and other habitat characteristics are suitable for the maintenance of a wide variety of reproducing populations of warm water fish and associated aquatic communities, including sensitive species.

(6) Limited resource warm water (Class "B(LR)"). Waters in which flow or other physical characteristics limit the ability of the water body to maintain a balanced warm water community. Such waters support only populations composed of species able to survive and reproduce in a wide range of physical and chemical conditions, and are not generally harvested for human consumption.

(7) Lakes and wetlands (Class "B(LW)"). These are artificial and natural impoundments with hydraulic retention times and other physical and chemical characteristics suitable to maintain a balanced community normally associated with lake-like conditions.

(8) Drinking water supply (Class "C"). Waters which are used as a raw water source of potable water supply.

61.3(2) *General water quality criteria.* The following criteria are applicable to all surface waters including general use and designated use waters, at all places and at all times to protect livestock and wildlife watering, aquatic life, noncontact recreation, crop irrigation, and industrial, domestic, agricultural and other incidental water withdrawal uses not protected by the specific numerical criteria of subrule 61.3(3).

a. Such waters shall be free from substances attributable to point source wastewater discharges that will settle to form sludge deposits.

b. Such waters shall be free from floating debris, oil, grease, scum and other floating materials attributable to wastewater discharges or agricultural practices in amounts sufficient to create a nuisance.

c. Such waters shall be free from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor or other aesthetically objectionable conditions.

d. Such waters shall be free from substances attributable to wastewater discharges or agricultural practices in concentrations or combinations which are acutely toxic to human, animal, or plant life.

e. Such waters shall be free from substances, attributable to wastewater discharges or agricultural practices, in quantities which would produce undesirable or nuisance aquatic life.

f. The turbidity of the receiving water shall not be increased by more than 25 Nephelometric turbidity units by any point source discharge.

g. Total dissolved solids shall not exceed 750 mg/l in any lake or impoundment or in any stream with a flow rate equal to or greater than three times the flow rate of upstream point source discharges.

h. Water which enters a sinkhole or losing stream segment shall not exceed a fecal coliform content of 200 organisms/100 ml, except when the waters are materially affected by surface runoff; but in no case shall fecal coliform levels downstream from an existing discharge which may contain pathogens to humans be more than 200 organisms/100 ml higher than the background level upstream from the discharge. No new wastewater discharges will be allowed on watercourses which directly or indirectly enter sinkholes or losing stream segments.

61.3(3) *Specific water quality criteria.*

a. *Class "A" waters.* Waters which are designated as Class "A" in subrule 61.3(5) are to be protected for primary contact recreation. The general criteria of subrule 61.3(2) and the following specific criteria apply to all Class "A" waters.

(1) From April 1 through October 31, the fecal coliform content shall not exceed 200 organisms/100 ml, except when the waters are materially affected by surface runoff; but in no case shall fecal coliform levels downstream from a discharge which may contain pathogens to humans be more than 200 organisms/100 ml higher than the background level upstream from the discharge.

(2) The pH shall not be less than 6.5 nor greater than 9.0. The maximum change permitted as a result of a waste discharge shall not exceed 0.5 pH units.

b. *Class "B" waters.* All waters which are designated as Class B(CW), B(WW), B(LR), or B(LW) are to be protected for wildlife, fish, aquatic and semiaquatic life, and secondary contact water uses. The following criteria shall apply to all Class "B" waters designated in subrule 61.3(5).

(1) Dissolved oxygen. Dissolved oxygen shall not be less than the values shown in Table 2 of this subrule.

(2) pH. The pH shall not be less than 6.5 nor greater than 9.0. The maximum change permitted as a result of a waste discharge shall not exceed 0.5 pH units.

(3) General chemical constituents. The specific numerical criteria shown in Tables 1, 2, and 3 of this subrule apply to all waters designated in subrule 61.3(5). The sole determinant of compliance with these criteria will be established by the department on a case-by-case basis. Effluent monitoring or instream monitoring, or both, will be the required approach to determine compliance.

1. The acute criteria represent the level of protection necessary to prevent acute toxicity to aquatic life. Instream concentrations above the acute criteria will be allowed only within the boundaries of the zone of initial dilution.

2. The chronic criteria represent the level of protection necessary to prevent chronic toxicity to aquatic life. Excursions above the chronic criteria will be allowed only inside of mixing zones or only for short-term periods outside of mixing zones; however, these excursions cannot exceed the acute criteria shown in Tables 1 and 3. The chronic criteria will be met as short-term average conditions at all times the flow equals or exceeds either the seven-day, ten-year flow or any site-specific low flow established under the provisions of subrule 61.2(5).

3. The human health criteria represent the level of protection necessary, in the case of noncarcinogens, to prevent adverse health effects in humans, and in the case of carcinogens, to prevent a level of incremental cancer risk not exceeding 1 in 100,000. Instream concentrations in excess of the human health criteria will be allowed only within the boundaries of the mixing zone.

(4) The waters shall contain no substances in concentrations which will make fish or shellfish inedible due to undesirable tastes or cause a hazard to humans after consumption.

(5) Temperature.

1. No heat shall be added to interior streams or the Big Sioux River that would cause an increase of more than 3°C. The rate of temperature change shall not exceed 1°C per hour. In no case shall heat be added in excess of that amount that would raise the stream temperature above 32°C.

2. No heat shall be added to streams designated as cold water fisheries that would cause an increase of more than 2°C. The rate of temperature change shall not exceed 1°C per hour. In no case shall heat be added in excess of that amount that would raise the stream temperature above 20°C.

3. No heat shall be added to lakes and reservoirs that would cause an increase of more than 2°C. The rate of temperature change shall not exceed 1°C per hour. In no case shall heat be added in excess of that amount that would raise the temperature of the lake or reservoirs above 32°C.

4. No heat shall be added to the Missouri River that would cause an increase of more than 3°C. The rate of temperature change shall not exceed 1°C per hour. In no case shall heat be added that would raise the stream temperature above 32°C.

5. No heat shall be added to the Mississippi River that would cause an increase of more than 3°C. The rate of temperature change shall not exceed 1°C per hour. In addition, the water temperature at representative locations in the Mississippi River shall not exceed the maximum limits in the table below during more than 1 percent of the hours in the 12-month period ending with any month. Moreover, at no time shall the water temperature at such locations exceed the maximum limits in the table below by more than 2°C.

Zone II—Iowa-Minnesota state line to the northern Illinois border (Mile Point 1534.6)

Zone III—Northern Illinois border (Mile Point 1534.6) to Iowa-Missouri state line.

Month	Zone II	Zone III
January	4°C	7°C
February	4°C	7°C
March	12°C	14°C
April	18°C	20°C
May	24°C	26°C
June	29°C	29°C
July	29°C	30°C
August	29°C	30°C
September	28°C	29°C
October	23°C	24°C
November	14°C	18°C
December	9°C	11°C

c. *Class "C" waters.* Waters which are designated as Class "C" are to be protected as a raw water source of potable water supply. The following criteria shall apply to all Class "C" waters designated in subrule 61.3(5).

(1) Radioactive substances.

1. The combined radium-226 and radium-228 shall not exceed 5 picocuries per liter at the point of withdrawal.

2. Gross alpha particle activity (including radium-226 but excluding radon and uranium) shall not exceed 15 picocuries per liter at the point of withdrawal.

3. The average annual concentration at the point of withdrawal of beta particle and photon radioactivity from man-made radionuclides other than tritium and strontium-90 shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year.

4. The average annual concentration of tritium shall not exceed 20,000 picocuries per liter at the point of withdrawal; the average annual concentration of strontium-90 shall not exceed 8 picocuries per liter at the point of withdrawal.

(2) All substances toxic or detrimental to humans or detrimental to treatment process shall be limited to nontoxic or nondetrimental concentrations in the surface water.

(3) The pH shall not be less than 6.5 nor greater than 9.0.

TABLE 1: Criteria for Chemical Constituents
(all values as micrograms per liter unless noted otherwise)

Human health criteria for carcinogenic parameters noted below were based on the prevention of an incremental cancer risk of 1 in 100,000. For parameters not having a noted human health criteria, the U.S. Environmental Protection Agency has not developed final national guideline values. For noncarcinogenic parameters, the recommended EPA criterion was selected. For Class C water, the EPA criteria for fish and water consumption were selected using the same considerations for carcinogenic and noncarcinogenic parameters as noted above.

		Use Designations				
Parameter		B(CW)	B(WW)	B(LR)	B(LW)	C
Alachlor	Acute	—	—	—	—	2
Aluminum	Chronic	87	3290	3290	742	—
	Acute	1435	9256	9256	1073	—
Antimony	Acute	—	—	—	—	6
Arsenic (III)	Chronic	200	200	1000	200	—
	Acute	360	360	1800	360	50
	Human Health	50	50	—	50	—
Asbestos	Acute	—	—	—	—	7(a)
Atrazine	Acute	—	—	—	—	3
Barium	Acute	—	—	—	—	2000
Benzene	Acute	—	—	—	—	5
	Human Health	712.8	712.8	—	712.8	—
Benzo(a)Pyrene	Acute	—	—	—	—	.2
Beryllium	Acute	—	—	—	—	4
Cadmium	Chronic	1	15	25	1	—
	Acute	4	75	100	4	5
	Human Health +	168	168	—	168	—
Carbofuran	Acute	—	—	—	—	40
Carbon Tetrachloride	Acute	—	—	—	—	5
	Human Health	44.2	44.2	—	44.2	—
Chloride	Acute	—	—	—	—	250*

Chlordane	Chronic	.004	.004	.15	.004	—
	Acute	2.5	2.5	2.5	2.5	2
	Human Health	.006	.006	—	.006	—
Chlorobenzene	Human Health +	20	20	—	20	20
Chloropyrifos	Chronic	.041	.041	.041	.041	—
	Acute	.083	.083	.083	.083	—
Chromium (VI)	Chronic	40	40	200	10	—
	Acute	60	60	300	15	100
	Human Health +	3365	3365	—	3365	—
Copper	Chronic	20	35	55	10	—
	Acute	30	60	90	20	1000
	Human Health +	1000	1000	—	1000	—
Cyanide	Chronic	5	10	10	10	—
	Acute	20	45	45	45	200(b)
Dalapon	Acute	—	—	—	—	200
Dibromochloropropane	Acute	—	—	—	—	.2
4,4-DDT + +	Chronic	.001	.001	.029	.001	—
	Acute	.9	.8	.95	.55	—
	Human Health	.0059	.0059	—	.0059	.0059
o-Dichlorobenzene	Acute	—	—	—	—	600
para-Dichlorobenzene	Acute	—	—	—	—	75
	Human Health +	2.6*	2.6*	—	2.6*	—
3,3-Dichloro/benzidine	Human Health	.2	.2	—	.2	.1
1,2-Dichloroethane	Acute	—	—	—	—	5
	Human Health	986	986	—	986	—
1,1-Dichloroethylene	Acute	—	—	—	—	7
	Human Health	32	32	—	32	—
cis-1, 2-Dichloroethylene	Acute	—	—	—	—	70
trans-1, 2-Dichlorethylene	Acute	—	—	—	—	100
Dichloromethane	Acute	—	—	—	—	5
1, 2-Dichloropropane	Acute	—	—	—	—	5

Di(2-Ethylhexyl)adipate	Acute	—	—	—	—	400
Di(2-ethylhexyl)phthalate	Acute	—	—	—	—	6
Dieldrin	Chronic	.0019	.0019	.50	.0019	—
	Acute	1.25	2.1	2.1	2.1	—
	Human Health	.0014	.0014	—	.0014	.0014
Dinoseb	Acute	—	—	—	—	7
2,3,7,8-TCDD (Dioxin)	Acute	—	—	—	—	.00003
	Human Health	.00014†	.00014†	—	.00014†	—
Diquat	Acute	—	—	—	—	20
2,4-D	Acute	—	—	—	—	70
Endosulfan	Chronic	.056	.15	.15	.15	—
	Acute	.11	.3	.3	.3	—
	Human Health	2400	2400	—	2400	1100
Endothall	Acute	—	—	—	—	100
Endrin	Chronic	.0023	.0023	.09	.0023	—
	Acute	.18	.18	.18	.18	2
	Human Health	8.1	8.1	—	8.1	—
Ethylbenzene	Acute	—	—	—	—	700
Ethylene dibromide	Acute	—	—	—	—	.05
Fluoride	Acute	—	—	—	—	4000
Glyphosate	Acute	—	—	—	—	700
Heptachlor	Chronic	.0038	.0038	.01	.0038	—
	Acute	.38	.38	.38	.38	.4
	Human Health	.002	.002	—	.002	—
Heptachlor epoxide	Acute	—	—	—	—	.2
Hexachlorobenzene	Acute	—	—	—	—	1
y-Hexachlorocyclohexane (Lindane)	Chronic	.25	.33	.33	.33	—
	Acute	3.2	4.1	4.1	4.1	.2
	Human Health	.63	.63	—	.63	—
Hexachlorocyclopentadiene	Acute	—	—	—	—	50

Lead	Chronic	3	30	80	3	—
	Acute	80	200	750	80	50
Mercury (II)	Chronic	.05	.05	.25	.05	—
	Acute	6.5	6.5	10	2.5	2
	Human Health +	.15	.15	—	.15	—
Methoxychlor	Acute	—	—	—	—	40
Monochlorobenzene	Acute	—	—	—	—	100
Nickel	Chronic	350	650	750	150	—
	Acute	3250	5800	7000	1400	—
	Human Health +	4584	4584	—	4584	—
Nitrate as N	Acute	—	—	—	—	10*
Nitrate + Nitrite as N	Acute	—	—	—	—	10*
Nitrite as N	Acute	—	—	—	—	1*
Oxamyl (Vydate)	Acute	—	—	—	—	200
Parathion	Chronic	.013	.013	.013	.013	—
	Acute	.065	.065	.065	.065	—
Pentachlorophenol (PCP)	Chronic	(d)	(d)	(d)	(d)	—
	Acute	(d)	(d)	(d)	(d)	1
	Human Health	82	82	—	82	—
Picloram	Acute	—	—	—	—	500
Polychlorinated Biphenyls	Chronic	.014	.014	1	.014	—
(PCBs)	Acute	2	2	2	2	.5
	Human Health	.0004	.0004	—	.0004	.0004
Polynuclear Aromatic	Chronic	.03	.03	3	.03	—
Hydrocarbons (PAHs)**	Acute	30	30	30	30	—
	Human Health	.3	.3	—	.3	.028
Phenols	Chronic	50	50	50	50	—
	Acute	1000	2500	2500	1000	50
	Human Health +	300	300	—	300	—
Selenium (VI)	Chronic	10	125	125	70	—
	Acute	15	175	175	100	50
Silver	Chronic	2.5	8.5	8.5	.35	—
	Acute	30	100	100	4	50

2,4,5-TP (Silvex)	Acute	—	—	—	—	50
Simazine	Acute	—	—	—	—	4
Styrene	Acute	—	—	—	—	100
Tetracholorethylene	Acute	—	—	—	—	5
Thallium	Acute	—	—	—	—	2
Toluene	Chronic	50	50	150	50	—
	Acute	2500	2500	7500	2500	1000
	Human Health +	300*	300*	—	300*	—
Total Residual Chlorine (TRC)	Chronic	10	20	25	10	—
	Acute	35	35	40	20	—
Toxaphene	Chronic	.0002	.0002	.019	.0002	—
	Acute	.81	.73	.79	.73	3
	Human Health	.0075	.0075	—	.0075	—
1,2,4-Trichlorobenzene	Acute	—	—	—	—	70
1,1,1-Trichlorethane	Acute	—	—	—	—	200
	Human Health +	173*	173*	—	173*	—
1,1,2-Trichloroethane	Acute	—	—	—	—	5
Trichloroethylene (TCE)	Chronic	80	80	80	80	—
	Acute	4000	4000	4000	4000	5
	Human Health	807	807	—	807	—
Trihalomethanes (total)(c)	Acute	—	—	—	—	100
Vinyl Chloride	Acute	—	—	—	—	2
	Human Health	5250	5250	—	5250	—
Xylenes (Total)	Acute	—	—	—	—	10*
Zinc	Chronic	200	450	2000	100	—
	Acute	220	500	2200	110	1000
	Human Health +	5000	5000	—	5000	—

* units expressed as milligrams/liter

** to include the sum of known and suspected carcinogenic PAHs

† expressed as nanograms/liter

\+ Represents the noncarcinogenic human health parameters

++ The concentrations of 4,4-DDT or its metabolites; 4,4-DDE and 4,4-DDD, individually shall not exceed the human health criterion.

(a) units expressed as million fibers/liter (longer than 10 micrometers)

(b) measured as free cyanide

(c) total trihalomethanes includes the sum of bromodichloromethane, dibromochloromethane, tribromomethane (bromoform), and trichloromethane (chloroform)

(d) Class B numerical criteria are a function of pH using the equation: Criterion ($\mu g/l$)=$e^{[1.005(pH) - x]}$, where e = 2.71828 and x varies according to the following table.

	B(CW)	B(WW)	B(LR)	B(LW)
Acute	3.65	4.83	3.34	4.83
Chronic	4.11	5.29	3.80	5.29

TABLE 2: Criteria for Dissolved Oxygen
(all values expressed in milligrams per liter as N)

	B(CW)	B(WW)	B(LR)	B(LW)
Minimum value for at least 16 hours of every 24-hour period	7.0	5.0	5.0	5.0*
Minimum value at any time during every 24-hour period	5.0	5.0	4.0	5.0*

**applies only to the upper layer of stratification in lakes*

TABLE 3a: Criteria for Ammonia Nitrogen -- Cold Water Streams
(all values expressed in milligrams per liter as Nitrogen)

Temp.°C		pH											
		6.5	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0
1.0	Acute	28.5	22.9	19.7	16.0	12.4	9.2	6.5	4.1	2.6	1.7	1.0	.7
	Chronic	5.7	4.6	3.9	3.2	2.5	1.8	1.3	0.8	0.5	0.3	.2	.1
5.0	Acute	27.0	21.7	18.7	15.2	11.8	8.7	6.2	3.9	2.5	1.6	1.0	.7
	Chronic	5.4	4.3	3.7	3.0	2.4	1.7	1.2	0.8	0.5	.3	.2	.1
10.0	Acute	25.6	20.6	17.7	14.5	11.2	8.3	5.9	3.8	2.4	1.6	1.0	.7
	Chronic	5.1	4.1	3.5	2.9	2.2	1.7	1.2	0.8	0.5	.3	.2	.1
15.0	Acute	24.6	19.8	17.0	13.9	10.8	8.0	5.7	3.7	2.4	1.5	1.0	.7
	Chronic	4.9	4.0	3.4	2.8	2.2	1.6	1.1	0.7	0.5	.3	.2	.1
20.0	Acute	24.0	19.3	16.6	13.6	10.6	7.9	5.6	3.6	2.4	1.5	1.0	.7
	Chronic	4.8	3.9	3.3	2.7	2.1	1.6	1.1	0.7	0.5	.3	.2	.1
25.0	Acute	16.7	13.5	11.6	9.5	7.4	5.5	4.0	2.6	1.7	1.2	.8	.6

	Chronic	3.3	2.7	2.3	1.9	1.5	1.1	0.8	0.5	0.3	.2	.2	.1
30.0	Acute	11.8	9.6	8.2	6.8	5.3	4.0	2.9	1.9	1.3	.9	.6	.5
	Chronic	2.4	1.9	1.6	1.4	1.1	0.8	0.6	0.4	0.3	.2	.1	.1

TABLE 3b: Criteria for Ammonia Nitrogen -- Warm Water Streams and Lakes
(all values expressed in milligrams per liter as Nitrogen)

Temp. °C		pH											
		6.5	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0
1.0	Acute	49.0	39.5	33.8	27.6	21.4	15.8	11.2	7.1	4.5	2.9	1.8	1.2
	Chronic	9.8	7.9	6.8	5.5	4.3	3.2	2.2	1.4	0.9	0.6	.4	.2
5.0	Acute	46.4	37.4	32.1	26.2	20.3	15.0	10.6	6.8	4.3	2.8	1.8	1.2
	Chronic	9.3	7.5	6.4	5.2	4.1	3.0	2.1	1.4	0.9	.6	.4	.2
10.0	Acute	44.0	35.5	30.5	24.9	19.3	14.3	10.1	6.5	4.1	2.7	1.8	1.2
	Chronic	8.8	7.1	6.1	5.0	3.9	2.9	2.0	1.3	0.8	.5	.4	.2
15.0	Acute	42.3	34.1	29.3	24.0	18.6	13.8	9.8	6.3	4.1	2.7	1.8	1.2
	Chronic	8.5	6.8	5.9	4.8	3.7	2.8	2.0	1.3	0.8	.5	.4	.2
20.0	Acute	41.2	33.3	28.6	23.4	18.2	13.5	9.7	6.2	4.1	2.7	1.8	1.2
	Chronic	8.2	6.7	5.7	4.7	3.6	2.7	1.9	1.2	0.8	.5	.4	.2
25.0	Acute	40.7	32.9	28.3	23.2	18.1	13.5	9.7	6.3	4.2	2.7	1.8	1.2
	Chronic	8.1	6.6	5.7	4.6	3.6	2.7	1.9	1.3	0.8	.5	.4	.2
30.0	Acute	20.4	16.5	14.2	11.7	9.1	6.8	5.0	3.3	2.2	1.5	1.1	.8
	Chronic	4.1	3.3	2.8	2.3	1.8	1.4	1.0	0.7	0.4	.3	.2	.2

TABLE 3c: Criteria for Ammonia Nitrogen -- Limited Resource Streams
(all values expressed in milligrams per liter as Nitrogen)

Temp.°C		pH											
		6.5	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0
1.0	Acute	71.5	57.6	49.4	40.3	31.2	23.0	16.3	10.3	6.6	4.2	2.6	1.7
	Chronic	14.3	11.5	9.9	8.1	6.2	4.6	3.3	2.1	1.3	0.8	.5	.3
5.0	Acute	67.8	54.6	46.8	38.2	29.6	21.9	15.5	9.9	6.3	4.0	2.6	1.7
	Chronic	13.6	10.9	9.4	7.6	5.9	4.4	3.1	2.0	1.3	.8	.5	.3
10.0	Acute	64.2	51.8	44.4	36.3	28.2	20.8	14.8	9.4	6.1	3.9	2.6	1.7
	Chronic	12.8	10.4	8.9	7.3	5.6	4.2	3.0	1.9	1.2	.8	.5	.3
15.0	Acute	61.8	49.8	42.8	35.0	27.2	20.1	14.3	9.2	5.9	3.9	2.6	1.8
	Chronic	12.4	10.0	8.6	7.0	5.4	4.0	2.9	1.8	1.2	.8	.5	.4
20.0	Acute	60.2	48.6	41.7	34.2	26.6	19.7	14.1	9.1	6.0	4.0	2.7	1.9
	Chronic	12.0	9.7	8.3	6.8	5.3	3.9	2.8	1.8	1.2	.8	.5	.4

25.0	Acute	59.4	48.0	41.3	33.8	26.4	19.7	14.2	9.2	6.1	4.0	2.7	1.9
	Chronic	11.9	9.6	8.3	6.8	5.3	3.9	2.8	1.8	1.2	.8	.5	.4
30.0	Acute	29.7	24.1	20.7	17.0	13.3	10.0	7.2	4.8	3.2	2.2	1.6	1.2
	Chronic	5.9	4.8	4.1	3.4	2.7	2.0	1.4	1.0	0.6	.4	.3	.2

61.3(4) *Class "C" waters.* Rescinded IAB 4/18/90, effective 5/23/90.

61.3(5) *Surface water classification.*

a. Water use designation abbreviations.

(1) "A" means primary body contact recreation.

(2) "B" means wildlife, aquatic life, and secondary body contact uses. "WW" means significant resource warm water, "LR" means limited resource warm water, "LW" means lakes and wetlands warm water, "CW" means cold water.

(3) "C" means raw water source of potable water supply.

b. Key to the order of streams.

(1) Streams are listed in downstream to upstream sequence within a basin.

(2) Major streams (1st order) are described in entirety from downstream end to upstream end, before listing their tributary (2nd order) streams, or the next (major) stream.

(3) Tributary (2nd order) streams (if any) are then listed in downstream to upstream sequence, and each is described in entirety before listing its tributaries (3rd order), or before listing the next upstream 2nd order tributary.

(4) When a stream and all its tributaries are described in entirety, the next upstream equal order stream is then listed and described.

(5) The scheme is repeated through 3rd, 4th and 5th orders, as necessary.

(6) The relationship of tributaries is indicated in the list by the spacing from the left margin. Names of tributaries are indented two spaces from the name of the stream to which they are tributary, and equal order streams fall one below the other on the same margin.

Example:

(I) River
  (A) River
  (B) River
    (1) Creek
    (2) Creek
      (a) Creek
    (3) Creek
  (C) River
(II) River

(I) and (II) are first order streams and (II) is upstream from (I). (A), (B) and (C) are tributaries of (I). (B) is upstream from (A), and (C) is upstream from (B). (1), (2) and (3) are tributaries of (B). (2) is upstream from (1), and (3) is upstream from (2). (a) is a tributary of (2).

(7) Stream names are in accordance with "Drainage Areas of Iowa Streams," U.S. Geological Survey, March 1974, except that locally known names are used for streams not listed therein.

c. *Stream abbreviations.*

(1) "R" means river.

(2) "Cr." means creek.

(3) "Br." means branch.

(4) "D.D." means drainage ditch.

(5) "E," "W," "N," and "S" are compass directions.

(6) "Fk." means fork.

(7) "aka" means also known as.

d. *Location abbreviations.*

(1) "R" means range.

(2) "T" means township.

(3) "S" means section.

(4) "Rd." means road.

(5) "Hwy." means highway.

(6) "Co." means county.

(7) "St." means street.

Iowa Water Quality Standards
Water Use Designations

e.

WESTERN IOWA RIVER BASINS

Western Iowa River Basins (Missouri, Big Sioux, and Little Sioux Rivers)

The streams or stream segments named below in alphabetical order are referenced within the Water Use Designations for the Western Iowa River Basins. Reference numbers provided in the alphabetical list correspond to numbered stream segments in the Water Use Designations.

Ashton Cr. - 39
Bacon Cr. - 37
Battle Cr. - 29
Beaver Cr. - 20
Big Cr. - 36
Big Muddy Cr. - 57
Big Sioux R. - 76
Boyer R. - 11
Boyer R. - 12
Broken Kettle Cr. - 77
Brooke Cr. - 48
Bull Run - 78
Deep Cr. - 73
Dry Run - 59
Dugout Cr. - 62
East Boyer R. - 14
East Soldier R. - 19
Elk Cr. - 31
Floyd R. - 68
Floyd R. - 69
Fox Run - 49
Gray Cr. - 44
Halfway Cr. - 33
Henry Cr. - 47
Indian Cr. - 79
Johns Cr. - 28
Jordan Cr. - 18
Kanaranzi Cr. - 87
Keg Cr. - 5
Lake Manawa water intake - 8
Little Floyd R. - 74
Little Maple R. - 34
Little Ocheyedan R. - 55
Little Rock R. - 84
Little Sioux R. - 21
Little Sioux R. - 22
Little Sioux R. - 23
Little Sioux R. - 25
Little Sioux R. - 24
Lost Island Outlet - 52
Maple Cr. - 35
Maple R. - 26
Maple R. -27
Milford Cr. - 60
Mill Cr. - 43
Mink Cr. – 71
Missouri R. – 1
Missouri R. - 2
Monona Harrison Co. Ditc - 63
Montgomery Cr. - 51
Moser Cr. - 9
Mosquito Cr. - 6
Mosquito Cr. - 7
Mud Cr. - 65
Mud Cr. - 86
Ocheyedan R. - 58
Odebolt Cr. - 30
Otter Cr. - 15
Otter Cr. - 85
Perry Cr. - 75
Pickerel Run - 53
Pierson Cr. - 38
Pigeon Cr. - 10
Plum Cr. - 3
Prairie Cr. - 56
Rock Cr. - 41
Rock R. - 81
Rock R. - 82
Silver Cr. - 32
Silver Cr. - 42
Sixmile Cr. - 80
Soldier R. - 16
Soldier R. - 17
Stony Cr. - 54
Unnamed Cr. - 83
Unnamed Cr. - 88
Unnamed Cr. - 89
Waterman Cr. - 46
Waubonsie Cr. - 4
West Branch Floyd R. - 70
West Fork Little Sioux R.- 61
West Fork Little Sioux R. - 64
Whiskey Cr. - 66
Willow Cr. - 13
Willow Cr. - 40
Willow Cr. - 45
Willow Cr. - 50
Willow Cr. - 72
Wolf Cr. - 67

WESTERN MAJOR RIVER - MISSOURI R. AND ITS TRIBUTARIES MISSOURI R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Missouri R. 1. Iowa-Missouri state line to confluence with the Big Sioux R.	X	X						
Missouri R. 2. City of Council Bluffs Water Works Intakes						X		
PLUM CR. AND ITS TRIBUTARIES								
Plum Cr. 3. Mouth (S6, T69N, R43W, Fremont Co.) to confluence with an unnamed tributary (S29, T70N, R42W, Fremont Co.)			X					
WAUBONSIE CR. AND ITS TRIBUTARIES								
Waubonsie Cr. 4. Mouth (S8, T70N, R43W, Fremont Co.) to confluence with an unnamed tributary (S25, T71N, R43W, Mills Co.)			X					
KEG CR. AND ITS TRIBUTARIES								
Keg Cr. 5. Mouth (S6, T71N, R43W, Mills Co.) to confluence with an unnamed tributary (S 1/2, S35, T78N, R41W, Harrison Co.)			X					
MOSQUITO CR. AND ITS TRIBUTARIES								
Mosquito Cr. 6. Mouth (Pottawattamie Co.) to confluence with Little Mosquito Cr. (S29, T75N, R43W, Pottawattamie Co.)		X						
Mosquito Cr. 7. Confluence with Little Mosquito Cr. (Pottawattamie Co.) to confluence with Moser Cr. (S12, T80N, R40W, Shelby Co.)			X					
Lake Manawa water intake structure 8. Intake near the Norfolk and Western Railroad crossing in the middle of S7, T74N, R43W, Pottawattamie Co.						X		
Moser Cr. 9. Mouth (Shelby Co.) to confluence with an unnamed tributary (S30, T81N, R39W, Shelby Co.)			X					
PIGEON CR. AND ITS TRIBUTARIES								
Pigeon Cr. 10. Mouth (S3, T75N, R44W, Pottawattamie Co.) to confluence with North Pigeon Cr. (S5, T76, R43W, Pottawattamie Co.)			X					
BOYER R. AND ITS TRIBUTARIES								
Boyer R. 11. Mouth (Pottawattamie Co.) to confluence with an unnamed tributary (S 1/2, S33, T88N, R37W, Sac Co.)		X						
Boyer R. 12. Confluence with an unnamed tributary (S33, T88N, R37W, Sac Co.) to confluence with an unnamed tributary (SE 1/4, SW 1/4, S5, T89N, R37W, Sac Co.)			X					
Willow Cr. 13. Mouth (S28, T78N, R44W, Harrison Co.) to confluence South Willow Cr. (S27, T82N, R42W, Monona Co.)			X					
East Boyer R. 14. Mouth (S10, T83N, R39W, Crawford Co.) to confluence with an unnamed tributary (NW 1/4, S15, T84N, R37W, Crawford Co.)			X					

WESTERN MAJOR RIVER - MISSOURI R. AND ITS TRIBUTARIES BOYER R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Otter Cr. 15. Mouth (S18, T84N, R38W, Crawford Co.) to confluence with East Otter Cr. (NW 1/4, S13, T85N, R39W, Crawford Co.)			X					
SOLDIER R. AND ITS TRIBUTARIES								
Soldier R. 16. Mouth (Harrison Co.) to confluence with E. Soldier R.		X						
Soldier R. 17. Confluence with East Soldier River (S34, T84N, R42W, Monona Co.) to confluence with Little Soldier Cr. (S24, T86N, R40W, Ida Co.)			X					
Jordan Cr. 18. Mouth (S16, T82N, R43W, Monona Co.) to confluence with an unnamed tributary (SE 1/4, NE 1/4, S10, T83N, R43W, Monona Co.)			X					
East Soldier R. 19. Mouth (S34, T84N, R42W, Monona Co.) to confluence with Emigrant Cr. (S23, T84N, R41W, Crawford Co.)			X					
Beaver Cr. 20. Mouth (S1, T85N, R41W, Crawford Co.) to confluence with an unnamed tributary (NW 1/4, S9, T85N, R40W, Crawford Co.)			X					
LITTLE SIOUX R. AND ITS TRIBUTARIES								
Little Sioux R. 21. Mouth (Harrison Co.) to Hwy. 3 in Cherokee (S26, T92N, R40W, Cherokee Co.)		X						
Little Sioux R. 22. Hwy. 3 in Cherokee (S26, T92N, R40W, Cherokee Co.) to Linn Grove Dam (Buena Vista Co.)	X	X						X
Little Sioux R. 23. Linn Grove Dam (Buena Vista Co.) to Clay Co., S17, T96N, R36W (east corporate limit, Spencer)		X						X
Little Sioux R. 24. West Line, S17, T96N, R36W, Clay Co. to confluence with West Fork Little Sioux River (Dickinson Co.)		X						
Little Sioux R. 25. Confluence with W. Fork Little Sioux R. (S7, T99N, R37W Dickinson Co.) to the Iowa-Minnesota state line			X					
Maple R. 26. Mouth (S17, T83N, R44W, Monona Co.) to confluence with Silver Cr. (S13, T88N, R40W, Ida Co.)		X						
Maple R. 27. Confluence with Silver Cr. (S13, T88N, R40W, Ida Co.) to confluence with Maple Cr. (S5, T91N, R39W, Cherokee Co.)			X					
Johns Cr. (aka Clear Cr.) 28. Mouth (S24, T90N, R44W, Plymouth Co.) to confluence with Rathbun Cr. (S26, T91N, R44W, Plymouth Co.)			X					
Battle Cr. 29. Mouth (S26, T87N, R41W, Ida Co.) to confluence with an unnamed tributary (SW 1/4, S24, T88N, R41W, Ida Co.)			X					

WESTERN MAJOR RIVER - MISSOURI R. AND ITS TRIBUTARIES LITTLE SIOUX R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Odebolt Cr. 30. Mouth (Ida Co.) to confluence with an unnamed tributary (S24, T87N, R39W, Ida Co.)			X					
Elk Cr. 31. Mouth (S1, T87N, R40W, Ida Co.) to confluence with an unnamed tributary (W 1/2, S36, T88N, R39W, Ida Co.)			X					
Silver Cr. 32. Mouth (S13, T88N, R39W, Ida Co.) to confluence with South Silver Cr. (S16, T88N, R39W, Ida Co.)			X					
Halfway Cr. 33. Mouth (S22, T89N, R39W, Ida Co.) to confluence with unnamed tributary (SE 1/4, S24, T89N, R39W, Ida Co.)			X					
Little Maple R. 34. Mouth (SW 1/4, S34, T90N, R39W, Cherokee Co.) to confluence with an unnamed tributary (NE 1/4, S20, T90N, R38W, Buena Vista Co.)			X					
Maple Cr. 35. Mouth (S5, T91N, R39W, Cherokee Co.) to confluence with an unnamed tributary (W 1/2, S1, T91N, R39W, Cherokee Co.)			X					
Big Cr. 36. Mouth (S4, T87N, R43W, Woodbury Co.) to confluence with Coon Cr. (S35, T88N, R43W, Woodbury Co.)			X					
Bacon Cr. 37. Mouth (S1, T88N, R43W, Woodbury Co.) to confluence with an unnamed tributary (S2, T88N, R42W, Woodbury Co.)			X					
Pierson Cr. 38. Mouth (S34, T89N, R42W, Woodbury Co.) to confluence with an unnamed tributary (N 1/2, S20, T89N, R42W, Woodbury Co.)			X					
Ashton Cr. 39. Mouth (S7, T89N, R41W, Ida Co.) to confluence with an unnamed tributary (S3, T89N, R41W, Ida Co.)			X					
Willow Cr. 40. Mouth (S30, T90N, R41W, Cherokee Co.) to confluence with an unnamed tributary (N 1/2, S31, T91N, R41W, Cherokee Co.)			X					
Rock Cr. 41. Mouth (S10, T90N, R41W, Cherokee Co.) to confluence with an unnamed tributary (SE 1/4, S21, T91N, R41W, Cherokee Co.)			X					
Silver Cr. 42. Mouth (S32, T91N, R40W, Cherokee Co.) to confluence with an unnamed tributary (N 1/2, S22, T90N, R40W, Cherokee Co.)			X					
Mill Cr. 43. Mouth (S14, T92N, R40W, Cherokee Co.) to confluence with West Branch Mill Cr. (S4, T95N, R41W, O'Brien Co.)			X					

WESTERN MAJOR RIVER - MISSOURI R. AND ITS TRIBUTARIES LITTLE SIOUX R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Gray Cr. 44. Mouth (S10, T92N, R40W, Cherokee Co.) to confluence with an unnamed tributary (NE 1/4, S22, T93N, R40W, Cherokee Co.)			X					
Willow Cr. 45. Mouth (SW 1/4, S1, T93N, R41W, Cherokee Co.) to confluence with Nelson Cr. (S25, T94N, R41W, O'Brien Co.)			X					
Waterman Cr. 46. Mouth (S26, T94N, R39W, O'Brien Co.) to confluence with Epping Cr. (S36, T97N, R40W, O'Brien Co.)			X					
Henry Cr. 47. Mouth (S24, T94N, R39W, O'Brien Co.) to confluence with an unnamed tributary (S24, T94N, R39W, O'Brien Co.)			X					
Brooke Cr. 48. Mouth (SW 1/4, S11, T93N, R38W, Buena Vista Co.) to confluence with an unnamed tributary (Center of S 1/2, S24, T92N, R38W, Buena Vista Co.)			X					
Fox Run 49. Mouth (SW 1/4, S12, T93N, R38W, Buena Vista Co.) to confluence with an unnamed tributary (NE 1/4, S19, T93N, R37W, Buena Vista Co.)			X					
Willow Cr. 50. Mouth (S17, T94N, R36W, Clay Co.) to confluence with an unnamed tributary (NW 1/4, S31, T95N, R37W, Clay Co.)			X					
Montgomery Cr. 51. Mouth (S3, T94N, R36W, Clay Co.) to confluence with an unnamed tributary (NW 1/4, S11, T94N, R36W, Clay Co.)			X					
Lost Island Outlet 52. Mouth (Clay Co.) to confluence with Pickerel Run S17, T96N, R36W, Clay Co.)			X					
Pickerel Run 53. Mouth (Clay Co.) to confluence with an unnamed tributary (S31, T97N, R35W, Clay Co.)			X					
Stony Cr. 54. Mouth (Clay Co.) to confluence with an unnamed tributary (S27, T98N, R38W, Dickinson Co.)			X					
Little Ocheyedan R. 55. Mouth (Osceola Co.) to confluence with an unnamed tributary (NW 1/4, S4, T89N, R40W, Osceola Co.)			X					
Prairie Cr. 56. Mouth (S26, T96N, R36W, Clay Co.) to confluence with an unnamed tributary (S33, T96N, R36W, Clay Co.)			X					
Big Muddy Cr. 57. Mouth (S15, T96N, R36W, Clay Co.) to confluence with unnamed tributary (S17, T98N, R35W, Clay Co.)			X					
Ocheyedan R. 58. Mouth (Clay Co.) to the Iowa-Minnesota state line			X					

WESTERN MAJOR RIVER - MISSOURI R. AND ITS TRIBUTARIES LITTLE SIOUX R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Dry Run 59. Mouth (Osceola Co.) to confluence with an unnamed tributary (S17, T99N, R39W, Osceola Co.)			X					
Milford Cr. (aka Mill Cr.) 60. Mouth (Dickinson Co.) to confluence with an unnamed tributary (S18, T98N, R36W, Dickinson Co.)			X					
West Fork Little Sioux R. 61. Mouth (Dickinson Co.) to the Iowa-Minnesota state line			X					
Dugout Cr. 62. Mouth (Dickinson Co.) to confluence with the first upstream unnamed tributary (S15, T99N, R38W, Dickinson Co.)			X					
MONONA-HARRISON DITCH AND ITS TRIBUTARIES								
Monona Harrison Co. Ditch 63. Mouth (S21, T81N, R45W, Harrison Co.) to confluence with W. Fk. L. Sioux River (Ditch) (S12, T84N, R45W, Monona Co.)		X						
West Fork Little Sioux R. 64. Mouth (S12, T84N, R45W, Monona Co.) to confluence with an unnamed tributary (S3, T91N, R42W, Cherokee Co.)			X					
Mud Cr. 65. Mouth (S31, T89N, R44W, Woodbury Co.) to confluence with an unnamed tributary (S6, T89N, R44W, Woodbury Co.)			X					
Whiskey Cr. 66. Mouth (Plymouth Co.) to confluence with an unnamed tributary (NW 1/4, S11, T93N, R44W, Plymouth Co.)			X					
Wolf Cr. (aka including Haitz Ditch) 67. Mouth (S12, T84N, R45W, Monona Co.) to confluence with East Fork Wolf Cr. (S30, T87N, R43W, Woodbury Co.)			X					
FLOYD R. AND ITS TRIBUTARIES								
Floyd R. 68. Mouth (Woodbury Co.) to confluence with W. Br. Floyd R. (Plymouth Co.)		X						
Floyd R. 69. Confluence with W. Br. Floyd R. (Plymouth Co.) to confluence with North Fork (S30, T97N, R41W, O'Brien Co.)			X					
West Branch Floyd R. 70. Mouth (Plymouth Co.) to confluence with an unnamed tributary (NE 1/4, S18, T96N, R44W, Sioux Co.)			X					
Mink Cr. 71. Mouth to confluence with an unnamed tributary (NE 1/4, S21, T93N, R46W, Plymouth Co.)			X					
Willow Cr. 72. Mouth (Plymouth Co.) to confluence with an unnamed tributary (NE 1/4, Sec. 35, T94N, R43W, Plymouth Co.)			X					
Deep Cr. 73. Mouth (Plymouth Co.) to confluence with an unnamed tributary (NE 1/4, Sec. 35, T94N, R43W, Plymouth Co.)			X					

WESTERN MAJOR RIVER - MISSOURI R. AND ITS TRIBUTARIES FLOYD R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Little Floyd R. 74. Mouth (Sioux Co.) to confluence with Lamkin Cr. (S8, T96N, R42W, O'Brien Co.)			X					
PERRY CR. AND ITS TRIBUTARIES Perry Cr. 75. Mouth (S32, T89N, R47W, Woodbury Co.) to confluence with an unnamed tributary (S35, T91N, R47W, Plymouth Co.)			X					
BIG SIOUX R. AND ITS TRIBUTARIES Big Sioux R. 76. Mouth (Woodbury Co.) to Iowa-Minnesota state line	X	X						
Broken Kettle Cr. 77. Mouth (S9, T90N, R48W, Plymouth Co.) to confluence with an unnamed tributary (S19, T92N, R47W, Plymouth Co.)			X					
Bull Run 78. Mouth (S25, T92N, R48W, Plymouth Co.) to confluence with an unnamed tributary (S29, T92N, R47W, Plymouth Co.)			X					
Indian Cr. 79. Mouth (S9, T93N, R48W, Plymouth Co.) to confluence with an unnamed tributary (S33, T94N, R47W, Sioux Co.)			X					
Sixmile Cr. 80. Mouth (S28, T94N, R48W, Sioux Co.) to confluence with an unnamed tributary (S19, T95N, R46W, Sioux Co.)			X					
Rock R. 81. Mouth (Sioux Co.) to confluence with Kanaranzi Cr. (S28, T100N, R45W, Lyon Co.)		X						
Rock R. 82. Confluence with Kanaranzi Cr. (Lyon Co.) to the Iowa-Minnesota state line			X					
Unnamed Cr. 83. Mouth (S26, T97N, R47W, Sioux Co.) to confluence with an unnamed tributary (W 1/2, S14, T97N, R47W, Sioux Co.)			X					
Little Rock R. 84. Mouth (Lyon Co.) to the Iowa-Minnesota state line			X					
Otter Cr. 85. Mouth (Lyon Co.) to confluence with an unnamed tributary (S14, T99N, R42W, Osceola Co.)			X					
Mud Cr. 86. Mouth (Lyon Co.) to the Iowa-Minnesota state line			X					
Kanaranzi Cr. 87. Mouth (Lyon Co.) to the Iowa-Minnesota state line			X					
Unnamed Cr. 88. Mouth (S5, T96N, R47W, Sioux Co.) to confluence with an unnamed tributary (S29, T97N, R47W, Sioux Co.)			X					
Unnamed Cr. 89. Mouth (S16, T98N, R48W, Lyon Co.) to confluence with an unnamed tributary (S22, T98N, R48W, Lyon Co.)			X					

SOUTHERN IOWA RIVER BASINS

The streams or stream segments named below in alphabetical order are referenced within the Water Use Designations for the Southern Iowa River Basins. Reference numbers provided in the alphabetical list correspond to numbered stream segments in the Water Use Designations.

Bluegrass Cr. - 29
Brush Cr. - 95
Brush Cr. - 110
Brushy Cr. - 51
Camp Cr. - 24
Carter Cr. - 113
Chariton R. - 88
Chariton R. - 89
Chariton R. - 90
Chariton R. - 91
Chariton R. - 92
Chariton R. - 93
Cooper Cr. - 97
Crooked Cr. - 65
Davids Cr. - 28
Dick Cr. - 107
E. FK 102 R. - 52
E. FK 102 R. - 53
E. Nishnabotna R. - 19
E. Nishnabotna R. - 20
East Branch West Nishnabotna - 15
East Fork Grand R. - 69
East Fork Medicine Cr. - 82
East Nodaway R. - 39
East Nodaway R. - 40
East Platte R. - 60
East Tarkio Cr. - 32
Elk Cr. - 18
Elk Cr. - 73
Elkhorn Cr. - 25
Farm Cr. - 11
Fisher Cr. - 22
Fivemile Cr. - 111
Fourmile Cr. - 76
Fox R. - 115
Gard Branch - 59
Grand R. - 62
Grand R. - 63
Grand R. - 71
Grand R. - 72
Greybill Cr. - 12
Honey Cr. - 54
Honey Cr. - 108
Indian Cr. - 9
Indian Cr. - 23
Jackson Cr. - 103
Jim Cr. - 14
Jonathan Cr. - 81
Jordan Cr. - 13
Jordan Cr. - 102
Little R. - 78
Little Walnut Cr. - 99
Locust Cr. - 83
Long Cr. - 74
Lotts Cr. - 70
Middle Branch 102 R. - 48
Middle Fork 102 R. -50
Middle Fork Grand R. - 68
Middle Nodaway R. - 41
Middle Nodaway R. - 42
Middle Platte R. - 61
Middle Silver Cr. - 8
Mill Cr. - 21
Mud Cr. - 10
Ninemile Cr. - 106
Nishnabotna R. - 1
Nodaway R. - 34
Nodaway R. - 35
North Cr. - 86
North Fabius R. - 112
North Fox Cr. - 116
Packard Cr. - 94
Platte Branch - 55
Platte R. - 56
Platte R. - 57
Plum Cr. - 67
Rose Branch - 49
S. Shoal Cr. - 84
Sevenmile Cr. -38
Shoal Cr. - 87
Silver Cr. - 6
Silver Cr. - 7
South Cr. - 85
South Fork Chariton R. - 100
South Fox Cr. - 117
South Wyaconda R. - 114
Squaw Cr. - 66
Steel Cr. - 80
Tarkio R. - 31
Troublesome Cr. - 27
Turkey Cr. - 26
Turkey Cr. - 58
Twelvemile Cr. - 75
Unnamed Cr. - 96
Unnamed Cr. - 105
W. Jackson Cr. - 104
W. Nishnabotna R. - 2
W. Nishnabotna R. - 3
Walker Br. - 101
Walnut Cr. - 4
Walnut Cr. - 5
Walnut Cr. - 64
Walnut Cr. - 98
Weldon R. - 79
West Branch 102 R. - 46
West Branch 102 R. - 47
West Branch Cr. - 77
West Fork 102 R. - 44
West Fork 102 R. - 45
West Fork Middle Nodaway - 43
West Fork West Nishnabotna - 16
West Mill Cr. - 33
West Nodaway R. - 36
West Nodaway R. - 37
West Tarkio Cr. - 30
Willow Cr. - 17
Wolf Cr. - 109

SOUTHERN MAJOR RIVER - NISHNABOTNA R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Nishnabotna R. 1. Iowa-Missouri state line (Fremont Co.) to confluence of the E. Nishnabotna R. and the W. Nishnabotna R. (Fremont Co.)		X						

SOUTHERN MAJOR RIVER - NISHNABOTNA R. AND ITS TRIBUTARIES W. NISHNABOTNA R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
W. Nishnabotna R. 2. Mouth (Fremont Co.) to confluence with W. Fk. of W. Nishnabotna R. (Shelby Co.)		X						
W. Nishnabotna R. 3. Confluence with West Fork West Nishnabotna R. to confluence with an unnamed tributary (S34, T83N, R36W, Carroll Co.)			X					
Walnut Cr. 4. Mouth (S8, T69N, R41W, Fremont Co.) to confluence with an unnamed tributary (S30/31 line, T73N, R38W, Montgomery Co.)		X						
Walnut Cr. 5. Confluence with an unnamed tributary (S30/31 line, T73N, R38W, Montgomery Co.) to confluence with an unnamed tributary (S3, T76N, R38W, Pottawattamie Co.)			X					
Silver Cr. 6. Mouth (Mills Co.) to Hwy. 41 (Mills Co.)		X						
Silver Cr. 7. Mouth (S26, T71N, R41W, Mills Co.) to confluence with Little Silver Cr. (S34, T78N, R40W, Shelby Co.)			X					
Middle Silver Cr. 8. Mouth (S31, T74N, R41W, Pottawattamie Co.) to confluence with Little Silver Cr. (S12, T74N, R42W, Pottawattamie Co.)			X					
Indian Cr. 9. Mouth (S13, T72N, R41W, Mills Co.) to confluence with an unnamed tributary (S26, T72N, R40W, Mills Co.)			X					
Mud Cr. 10. Mouth (S31, T73N, R40W, Mills Co.) to confluence with an unnamed tributary (NW 1/4, S14, T73N, R41W, Mills Co.)			X					
Farm Cr. 11. Mouth (S9, T73N, R40W, Mills Co.) to confluence with Jordan Cr. (S31, T74N, R39W, Pottawattamie Co.)			X					
Greybill Cr. 12. Mouth (S36, T74N, R40W, Pottawattamie Co.) to confluence with unnamed tributary (NW 1/4, S21, T75N, R39W, Pottawattamie Co.)			X					
Jordan Cr. 13. Mouth (S31, T74N, R39W, Pottawattamie Co.) to confluence with Spring Cr. (S4, T74N, R39W, Pottawattamie Co.)			X					
Jim Cr. 14. Mouth (S32, T77N, R39W, Pottawattamie Co.) to confluence with an unnamed tributary (S33, T77N, R39W, Pottawattamie Co.)			X					
East Branch West Nishnabotna R. 15. Mouth (S29, T77N, R39W, Pottawattamie Co.) to confluence with Lone Willow Cr. (S9, T80N, R36W, Audubon Co.)			X					

SOUTHERN MAJOR RIVER - NISHNABOTNA R. AND ITS TRIBUTARIES W. NISHNABOTNA R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
West Fork West Nishnabotna R. 16. Mouth (Shelby Co.) to confluence with Maloney Branch (S29, T83N, R37W, Crawford Co.)			X					
Willow Cr. 17. Mouth (Shelby Co.) to confluence with an unnamed tributary (S3, T81N, R39W, Shelby Co.)			X					
Elk Cr. 18. Mouth (Shelby Co.) to confluence with an unnamed tributary (NW 1/4, S28, T82N, R37W, Crawford Co.)			X					
E. NISHNABOTNA R. AND ITS TRIBUTARIES								
E. Nishnabotna R. 19. Mouth (Fremont Co.) to confluence of Troublesome Creek (Cass Co.)		X						
E. Nishnabotna R. 20. Confluence with Troublesome Cr. (S32, T77N, R36W, Cass Co.) to confluence with an unnamed tributary (E 1/2, NW 1/4, S6, T80N R34W, Audubon Co.)			X					
Mill Cr. 21. Mouth (S31, T68N, R41W, Fremont Co.) to confluence with an unnamed tributary (SE 1/4, NW 1/4, S15, T67N, R41W, Fremont Co.)			X					
Fisher Cr. 22. Mouth (S27, T69N, R40W, Fremont Co.) to confluence with an unnamed tributary (S11/12 line, T68N, R40W, Fremont Co.)			X					
Indian Cr. 23. Mouth (S17, T75N, R37W, Cass Co.) to confluence with Wolf Cr. (S35, T79N, R37W, Shelby Co.)			X					
Camp Cr. 24. Mouth (S5/6 line, T77N, R37W, Cass Co.) to confluence with an unnamed tributary (S16, T77N, R37W, Cass Co.)			X					
Elkhorn Cr. 25. Mouth (S20, T78N, R37W, Shelby Co.) to confluence with an unnamed tributary (S10, T78N, R37W, Shelby Co.)			X					
Turkey Cr. 26. Mouth (S2, T75N, R37W, Cass Co.) to confluence with Eller Branch (S13, T76N, R36W, Cass Co.)			X					
Troublesome Cr. 27. Mouth (S32, T77N, R36W, Cass Co.) to confluence with Fourmile Cr. (S8, T78N, R34W, Audubon Co.)			X					
Davids Cr. 28. Mouth (S4, T78N, R35W, Audubon Co.) to confluence with Honey Cr. (S31, T79N, R34W, Audubon Co.)			X					
Bluegrass Cr. 29. Mouth (S14, T79N, R35W, Audubon Co.) to confluence with an unnamed tributary from the West (S34, T80N, R35W, Audubon Co.)			X					
MAJOR RIVER - WEST TARKIO CR. AND ITS TRIBUTARIES								
West Tarkio Cr. 30. Iowa-Missouri state line (Page Co.) to confluence with an unnamed tributary (S9, T69N, R38W, Page Co.)			X					

SOUTHERN MAJOR RIVER - TARKIO R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Tarkio R. 31. Iowa-Missouri state line (Page Co.) to confluence with East Tarkio Cr. (S4, T72N, R37W, Montgomery Co.)			X					
EAST TARKIO CR. AND ITS TRIBUTARIES East Tarkio Cr. 32. Mouth (S9, T68N, R38W, Page Co.) to confluence with an unnamed tributary (S7, T69N, R37W, Page Co.)			X					
MAJOR RIVER - WEST MILL CR. AND ITS TRIBUTARIES West Mill Cr. 33. Iowa-Missouri state line to confluence with an unnamed tributary (NE 1/4, S12, T67N, R38W, Page Co.)			X					
MAJOR RIVER - NODAWAY R. AND ITS TRIBUTARIES Nodaway R. 34. Iowa-Missouri state line (Page Co.) to confluence of Middle Nodaway R. and the W. Nodaway R. (Montgomery Co.)		X						
Nodaway R. 35. City of Clarinda Water Works intake						X		
WEST NODAWAY R. AND ITS TRIBUTARIES West Nodaway R. 36. Mouth (S33, T71N, R36W, Montgomery Co.) to confluence with Threemile Cr. (S35, T74N, R36W, Cass Co.)		X						
West Nodaway R. 37. Confluence with Threemile Cr. (S35, T74N, R36W, Cass Co.) to confluence with Whislers Branch (S17, T74N, R35W, Cass Co.)			X					
Sevenmile Cr. 38. Mouth (S33, T73N, R36W, Montgomery Co.) to confluence with Fourmile Cr. (S33, T75N, R36W, Cass Co.)			X					
EAST NODAWAY R. AND ITS TRIBUTARIES East Nodaway R. 39. Mouth (S6, T67N, R36W, Page Co.) to confluence with Long Branch (S17/18 line, T70N, R35W, Taylor Co.)		X						
East Nodaway R. 40. Confluence with Long Branch (S17/18 line, T70N, R35W, Taylor Co.) to confluence with Shanghai Cr. (S16, T73N, R32W, Adams Co.)			X					
Middle Nodaway R. 41. Mouth (Montgomery Co.) to confluence with West Fork Middle Nodaway (S33, T74N, R33W, Adair Co.)		X						
Middle Nodaway R. 42. Confluence with West Fork Middle Nodaway (Adair Co.) to confluence with an unnamed tributary (S1, T75N, R32W, Adair Co.)			X					
West Fork Middle Nodaway R. 43. Mouth (S33, T74N, R33W, Adair Co.) to confluence with Rutt Br. (S15, T75N, R33W, Adair Co.)			X					

SOUTHERN MAJOR RIVER - WEST FORK 102 R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
West Fork 102 R. 44. Iowa-Missouri state line to the confluence with the West Branch 102 R. (S10, T68N, R35W, Taylor Co.)		X						
West Fork 102 R. 45. Confluence with West Branch 102 R. (S10, T68N, R35W, Taylor Co.) to confluence with an unnamed tributary (S6, T70N, R34W, Taylor Co.)			X					
WEST BRANCH 102.R AND ITS TRIBUTARIES West Branch 102 R. 46. Mouth (Taylor Co.) to confluence with Middle Branch 102 R. (S6, T69N, R34W, Taylor Co.)		X						
West Branch 102 R. 47. Confluence with Middle Branch 102 R. (S6, T69N, R34W, Taylor Co.) to confluence with Willow Cr. (S29, T71N, R33W, Adams Co.)			X					
Middle Branch 102 R. 48. Mouth (Taylor Co.) to bridge crossing at (S16/21, T70N, R33W, Taylor Co.)			X					
ROSE BRANCH AND ITS TRIBUTARIES Rose Branch 49. Mouth (Taylor Co.) to confluence with an unnamed tributary (S34, T71N, R34W, Adams Co.)			X					
MAJOR RIVER - MIDDLE FORK 102 R. AND ITS TRIBUTARIES Middle Fork 102 R. 50. Iowa-Missouri state line to Hwy. 149 bridge crossing (S22/23, T69N, R34W, Taylor Co.)			X					
BRUSHY CR. AND ITS TRIBUTARIES Brushy Cr. 51. Mouth (Taylor Co.) to confluence with an unnamed tributary (S24, T68N, R35W, Taylor Co.)			X					
MAJOR RIVER - E. FK 102 R. AND ITS TRIBUTARIES E. FK 102 R. 52. Iowa-Missouri state line to bridge crossing (Center, S8, T68N, R33W, Taylor Co.)		X						
E. FK 102 R. 53. City of Bedford Water Works intake						X		
MAJOR RIVER - HONEY CR. AND ITS TRIBUTARIES **HONEY CR. AND ITS TRIBUTARIES** Honey Cr. 54. Iowa-Missouri state line to confluence with an unnamed tributary (S14, T69N, R32W, Taylor Co.)			X					
MAJOR RIVER - PLATTE BRANCH AND ITS TRIBUTARIES Platte Branch 55. Iowa-Missouri state line to bridge crossing (S16/17, T68N, R32W, Taylor Co.)			X					
MAJOR RIVER - PLATTE R. AND ITS TRIBUTARIES Platte R. 56. Iowa-Missouri state line (S28, T67N, R32W, Taylor Co.) to confluence with an unnamed tributary (NE 1/4, S36, T68N, R32W, Taylor Co.)		X						

	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
SOUTHERN								
MAJOR RIVER - PLATTE R. AND ITS TRIBUTARIES								
Platte R.								
57. Confluence with an unnamed tributary (NE 1/4, S36, T68N, R32W, Taylor Co.) to confluence with an unnamed tributary (NE 1/4, S16, T72N, R31W, Union Co.)			X					
TURKEY CR. AND ITS TRIBUTARIES								
Turkey Cr.								
58. Mouth (Ringgold Co.) to confluence with an unnamed tributary (NE 1/4, S29, T69N, R31W, Ringgold Co.)			X					
GARD BRANCH AND ITS TRIBUTARIES								
Gard Branch								
59. Mouth (Ringgold Co.) to confluence with an unnamed tributary (SE 1/4, S20, T70N, R31W, Ringgold Co.)			X					
EAST PLATTE R. AND ITS TRIBUTARIES								
East Platte R.								
60. Mouth (S9, T70N, R31W, Ringgold Co.) to confluence with Middle Platte R. (S33, T71N, R31W, Union Co.)			X					
Middle Platte R.								
61. Mouth (S33, T71N, R31W, Union Co.) to confluence with East Branch Middle Platte R. (S16, T71N, R31W, Union Co.)			X					
MAJOR RIVER - GRAND R. AND ITS TRIBUTARIES								
Grand R.								
62. Iowa-Missouri state line (S30, T67N, R31W, Ringgold Co.) to confluence with Crooked Cr. (S5, T68N, R30W, Ringgold Co.)		X						
Grand R.								
63. Confluence with Crooked Cr. (S5, T68N, R30W, Ringgold Co.) to bridge crossing (S25/36 line, T71N, R30W, Union Co.)			X					
WALNUT CR. AND ITS TRIBUTARIES								
Walnut Cr.								
64. Mouth (Ringgold Co.) to confluence with an unnamed tributary (NE 1/4, S36, T69N, R30W, Ringgold Co.)			X					
CROOKED CR. AND ITS TRIBUTARIES								
Crooked Cr.								
65. Mouth (Ringgold Co.) to confluence with Brush Cr. (S28, T69N, R30W, Ringgold Co.)			X					
SQUAW CR. AND ITS TRIBUTARIES								
Squaw Cr.								
66. Mouth (Ringgold Co.) to confluence with an unnamed tributary (S27, T70N, R30W, Ringgold Co.)			X					
PLUM CR. AND ITS TRIBUTARIES								
Plum Cr.								
67. Mouth (Ringgold Co.) to confluence with West Plum Cr. (S18, T70N, R30W, Ringgold Co.)			X					
MAJOR RIVER - MIDDLE FORK GRAND R. AND ITS TRIBUTARIES								
Middle Fork Grand R.								
68. Iowa-Missouri state line (Ringgold Co.) to confluence with an unnamed tributary (S13, T68N, R30W, Ringgold Co.)			X					

SOUTHERN MAJOR RIVER - EAST FORK GRAND R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
East Fork Grand R. 69. Iowa-Missouri state line (Ringgold Co.) to confluence with Goosebury Cr. (S2, T68N, R29W, Ringgold Co.)			X					
MAJOR RIVER - LOTTS CR. AND ITS TRIBUTARIES **LOTTS CR. AND ITS TRIBUTARIES** Lotts Cr. 70. Iowa-Missouri state line (Ringgold Co.) to confluence with Tuckers Cr. (S12, T67N, R29W, Ringgold Co.)			X					
MAJOR RIVER - GRAND R. (AKA THOMPSON CR.) AND ITS TRIBUTUTARIES Grand R. (aka Thompson Cr.) 71. Iowa-Missouri state line (Decatur Co.) to confluence with Long Cr. (SW 1/4, S8, T69N, R26W, Decatur Co.)		X						
Grand R. (aka Thompson Cr.) 72. Confluence with Long Cr. (SW 1/4, S8, T69N, R26W, Decatur Co.) to confluence with Marvel Cr. (S8, T75N, R30W, Adair Co.)			X					
ELK CR. AND ITS TRIBUTARIES Elk Cr. 73. Mouth (S18, T68N, R26W, Decatur Co.) to confluence with an unnamed tributary (S20, T69N, R27W, Decatur Co.)			X					
LONG CR. AND ITS TRIBUTARIES Long Cr. 74. Mouth (S8, T69N, R26W, Decatur Co.) to confluence with East Long Creek (S36, T71N, R27W, Clarke Co.)			X					
TWELVEMILE CR. AND ITS TRIBUTARIES Twelvemile Cr. 75. Mouth (S36, T71N, R28W, Union Co.) to confluence with an unnamed tributary (NW 1/4, NE 1/4, S12, T71N, R29W, Union Co.)			X					
FOURMILE CR. AND ITS TRIBUTARIES Fourmile Cr. 76. Mouth (S2, T72N, R28W, Union Co.) to confluence with an unnamed tributary (E 1/2, S23, T72N, R28W, Union Co.)			X					
WEST BRANCH CR. AND ITS TRIBUTARIES West Branch Cr. 77. Mouth (S34, T74N, R29W, Madison Co.) to confluence with an unnamed tributary (E 1/2, S32, T74N, R29W, Madison Co.)			X					
MAJOR RIVER - LITTLE R. AND ITS TRIBUTARIES Little R. 78. Iowa-Missouri state line (Decatur Co.) to Dam at road crossing (SE 1/2, NW 1/4, S30, T69N, R25W, Decatur Co.)			X					
MAJOR RIVER - WELDON R. AND ITS TRIBUTARIES Weldon R. 79. Iowa-Missouri state line (Decatur Co.) to confluence with Mormon Pool (S28, T70N, R24W, Decatur Co.)			X					
STEEL CR. AND ITS TRIBUTARIES Steel Cr. 80. Mouth (S 10/11 line, T67N, R24W, Decatur Co.) to confluence with an unnamed tributary (NE 1/4, S11, T68N, R24W, Decatur Co.)			X					

SOUTHERN MAJOR RIVER - WELDON R. AND ITS TRIBUTARIES JOHNATHAN CR. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Jonathan Cr. 81. Mouth (S20, T69N, R24W, Decatur Co.) to confluence with Cobbville Cr. (W 1/2, S6, T69N, R24W, Decatur Co.)			X					
MAJOR RIVER - EAST FORK MEDICINE CR. AND ITS TRIBUTARIES East Fork Medicine Cr. 82. Iowa-Missouri state line (Wayne Co.) to confluence with an unnamed tributary (E 1/2, S24, T68N, R22W, Wayne Co.)			X					
MAJOR RIVER - LOCUST CR. AND ITS TRIBUTARIES Locust Cr. 83. Iowa-Missouri state line (Wayne Co.) to confluence with an unnamed tributary (S15, T67N, R20W, Wayne Co.)			X					
MAJOR RIVER - S. SHOAL CR. AND ITS TRIBUTARIES S. Shoal Cr. 84. Iowa-Missouri state line (Appanoose Co.) to confluence with North Cr. (N 1/2, S16, T67N, R18W, Appanoose Co.)			X					
SOUTH CR. AND ITS TRIBUTARIES South Cr. 85. Mouth (S 1/2, S16, T67N, R18W, Appanoose Co.) to confluence with an unnamed tributary (W 1/2, S17, T67N, R18W, Appanoose Co.)			X					
NORTH CR. AND ITS TRIBUTARIES North Cr. 86. Mouth (N 1/2, S16, T67N, R18W, Appanoose Co.) to confluence with an unnamed tributary (W 1/2, of SE 1/4, S8, T67N, R18W, Appanoose Co.)			X					
MAJOR RIVER - SHOAL CR. AND ITS TRIBUTARIES Shoal Cr. 87. Iowa-Missouri state line (Appanoose Co.) to confluence with an unnamed tributary (S28, T68N, R19W, Appanoose Co.)			X					
MAJOR RIVER - CHARITON R. AND ITS TRIBUTARIES Chariton R. 88. Iowa-Missouri state line (Appanoose Co.) to Hwy. 2 (Appanoose Co., S27, T69N, R17W)		X						
Chariton R. 89. Hwy. 2 (Appanoose Co., S27, T69N, R17W) to Rathbun Reservoir Dam (Appanoose Co., S35, T69N, R18W)		X						X
Chariton R. 90. Rathbun Regional Water Company water supply intake						X		
Chariton R. 91. Rathbun Reservoir Dam to upper extent of Rathbun Lake conservation pool	X	X						X
Chariton R. 92. Upper extent of Rathun Lake conservation pool to Highway 14 (Lucas Co.)			X					X
Chariton R. 93. Highway 14 (Lucas Co.) to confluence with Chariton Creek (S19, T71N, R23W, Lucas Co.)			X					

SOUTHERN MAJOR RIVER - CHARITON R. AND ITS TRIBUTARIES PACKARD CR. AND ITS TRIBUTARIES	A	(BWW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Packard Cr. 94. Mouth (S8, T67N, R16W, Appanoose Co.) to confluence with an unnamed tributary (S1, T67N, R17W, Appanoose Co.)			X					
Brush Cr. 95. Mouth (S6, T67N, R16W, Appanoose Co.) to confluence with an unnamed tributary (S22, T68N, R17W, Appanoose Co.)			X					
UNNAMED CR. AND ITS TRIBUTARIES Unnamed Cr. 96. Mouth (S17, T67N, R16W, Appanoose Co.) to confluence with an unnamed tributary (S14, T67N, R16W, Appanoose Co.)			X					
COOPER CR. AND ITS TRIBUTARIES Cooper Cr. 97. Mouth (Appanoose Co.) to confluence with an unnamed tributary (S9, T68N, R19W, Appanoose Co.)			X					
WALNUT CR. AND ITS TRIBUTARIES Walnut Cr. 98. Mouth (Appanoose Co.) to confluence with an unnamed tributary (S31, T69N, R19W, Appanoose Co.)			X					
Little Walnut Cr. 99. Mouth (Appanoose Co.) to confluence with Wolf Branch (S12, T69N, R19W, Appanoose Co.)			X					
SOUTH FORK CHARITON R. AND ITS TRIBUTARIES South Fork Chariton R. 100. Mouth (Lake Rathbun) to outfall of Bob White State Park Lake (S4, T68N, R22W, Wayne Co.)			X					
Walker Br. 101. Mouth (S36, T70N, R20W, Wayne Co.) to confluence with South Fork Walker Br. (SE 1/4, S26, T70N, R20W, Wayne Co.)			X					
Jordan Cr. 102. Mouth (S1, T70N, R21W, Wayne Co.) to confluence with an unnamed tributary (E 1/2, of the NW 1/4, S26, T70N, R21W, Wayne Co.)			X					
Jackson Cr. 103. Mouth (S1, T70N, R21W, Wayne Co.) to confluence with an unnamed tributary (S12, T68N, R21W, Wayne Co.)			X					
W. Jackson Cr. 104. Mouth (S25, T69N, R21W, Wayne Co.) to confluence with an unnamed tributary (S31, T69N, R21W, Wayne Co.)			X					
Unnamed Cr. 105. Mouth (S5, T69N, R21W, Wayne Co.) to confluence with an unnamed tributary (S7, T69N, R21W, Wayne Co.)			X					
Ninemile Cr. 106. Mouth (S4, T69N, R22W, Wayne Co.) to confluence with an unnamed tributary (S31, T70N, R22W, Wayne Co.)			X					
Dick Cr. 107. Mouth (S16, T69N, R22W, Wayne Co.) to confluence with an unnamed tributary (NE 1/4, S18, T69N, R22W, Wayne Co.)			X					

SOUTHERN MAJOR RIVER - CHARITON R. AND ITS TRIBUTARIES HONEY CR. AND ITS TRIBUTARIES	A	(BWW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Honey Cr. 108. Mouth (S26, T71N, R20W, Lucas Co.) to confluence with an unnamed tributary (S10, T71N, R20W, Lucas Co.)			X					
WOLF CR. AND ITS TRIBUTARIES Wolf Cr. 109. Mouth (S15, T71N, R21W, Lucas Co.) to confluence with an unnamed tributary (E 1/2, NW 1/4, S8, T70N, R22W, Wayne Co.)			X					
Brush Cr. 110. Mouth (S31, T71N, R21W, Lucas Co.) to confluence with an unnamed tributary (SW 1/4, S13, T70N, R22W, Wayne Co.)			X					
Fivemile Cr. 111. Mouth (S35, T71N, R22W, Lucas Co.) to confluence with an unnamed tributary (S29, T71N, R22W, Lucas Co.)			X					
MAJOR RIVER - NORTH FABIUS R. AND ITS TRIBUTARIES North Fabius R. 112. Iowa-Missouri state line to confluence with an unnamed tributary (Center, S33, T68N, R15W, Davis Co.)			X					
MAJOR RIVER - CARTER CR. AND ITS TRIBUTARIES Carter Cr. 113. Iowa-Missouri state line to confluence with an unnamed tributary (NW 1/4, S28, T68N, R14W, Davis Co.)			X					
MAJOR RIVER - SOUTH WYACONDA R. AND ITS TRIBUTARIES South Wyaconda R. 114. Iowa-Missouri state line to confluence with an unnamed tributary (NE 1/4, S19, T68N, R13W, Davis Co.)			X					
MAJOR RIVER - FOX R. AND ITS TRIBUTARIES Fox R. 115. Iowa-Missouri state line to confluence with an unnamed tributary (S29, T69N, R15W, Davis Co.)			X					
NORTH FOX CR. AND ITS TRIBUTARIES North Fox Cr. 116. Mouth (Davis Co.) to confluence with an unnamed tributary (S2, T69N, R15W, Appanoose Co.)			X					
SOUTH FOX CR. AND ITS TRIBUTARIES South Fox Cr. 117. Mouth (SE 1/4, S28, T69N, R15W, Davis Co.) to confluence with an unnamed tributary (S5, T68N, R15W, Davis Co.)			X					

DES MOINES RIVER BASIN

Des Moines River Basin (Lower Des Moines River, Upper Des Moines River, East Fork Des Moines River, Blue Earth River, and Raccoon River Subbasins).

The streams or stream segments named below in alphabetical order are referenced within the Water Use Designations for the Des Moines River Basin. Reference numbers provided in the alphabetical list correspond to numbered stream segments in the Water Use Designations.

Badger Cr. - 59
Badger Cr. - 162
Bay Branch - 88
Bear Cr. - 20
Bear Cr. - 80
Bear Cr. - 138
Beaver Cr. - 128
Beaver Cr. - 164
Beaver Cr. - 183
Big Cr. - 136
Big Creek - 134
Big Creek - 135
Black Cat Cr. - 171
Bloody Run - 169
Blue Earth R. - 187
Bluff Cr. - 140
Boone R. - 142
Boone R. - 143
Boone R. - 144
Boone R. - 145
Brush Cr. - 19
Brush Cr. - 36
Brushy Cr. - 153
Brushy Cr. - 154
Brushy Creek - 94
Brushy Creek - 95
Buck Cr. - 147
Buck Run - 126
Buffalo Cr. - 174
Buttrick Cr. - 105
Calhoun Cr. - 37
Camp Cr. - 38
Camp Cr. - 121
Cavitt Cr. - 46
Cedar Cr. - 28
Cedar Cr. - 29
Cedar Cr. - 60
Cedar Cr. - 110
Cedar Cr. - 111
Cedar Cr. - 124
Chequest Cr. - 15
Clanton Cr. - 47
Clanton Cr. - 48
Coal Cr. - 40
Competine Cr. - 32
Cylinder Cr. - 182
D.D. 94 - 149
Dead Brier Cr. - 104
Deer Cr. - 93
Deer Cr. - 163
Des Moines R. - 1
Des Moines R. - 2
Des Moines R. - 3
Des Moines R. - 4
Des Moines R. - 5
Des Moines R. - 6
Des Moines R. - 7
Des Moines R. - 8
Des Moines R. - 9
Des Moines R. - 10
Des Moines R. - 11
Des Moines R. - 12
Ditch No. 9 & 13 - 119
E Fk. Des Moines R. - 165
E Fk. Des Moines R. - 166
E Fk. Des Moines R. - 167
Eagle Cr. - 148
East Buttrick Cr. - 107
East Cedar Cr. - 112
East Fork Des Moines R. - 168
Elk Run - 116
English Cr. - 31
Fourmile Cr. - 67
Fourmile Cr. - 68
Greenbrier Cr. - 103
Hardin Cr. - 108
Hickory Cr. - 100
Honey Cr. - 139
Howerdon Cr. - 65
Indian Cr. - 123
Indian Cr. - 180
Jack Cr. - 185
Jim Cr. - 63
Jones Cr. - 49
Lake Cr. - 117
Lake Cr. - 118
Lick Cr. - 14
Lindsey Cr. - 173
Little Beaver Cr. - 129
Little Beaver Cr. - 130
Little Cedar Cr. - 125
Little Fourmile Cr. - 69
Little Soap Cr. - 18
Little White Breast Cr. - 35
Lizard Cr. - 157
Lizard Cr. - 158
Lotts Cr. - 170
Marrowbone Cr. - 115
Middle Avery Cr. - 24
Middle Beaver Cr. - 132
Middle Branch Boone R. - 152
Middle Cr. - 58
Middle R. - 43
Middle R. - 44
Middle R. - 45
Middle Raccoon R. - 81
Middle Raccoon R. - 82
Middle Raccoon R. - 83
Middle Raccoon R. - 84
Middle Raccoon R. - 85
Middle Raccoon R. - 86
Miller Cr. - 26
Mosquito Cr. - 87
Muchakinock Cr. - 27
Mud Cr. - 42
Mud Cr. - 177
N. Br. Lizard Cr. - 161
N. Raccoon R. - 96
N. Raccoon R. - 97
N. Raccoon R. - 99
North Avery Cr. - 25
North Branch North R. - 61
North Buffalo Cr. - 176
North Cedar Cr. - 30
North Fork Clanton Cr. - 51
North R. - 54
North R. - 55
North R. - 56
North R. - 57
North Raccoon River - 98
Old Channel - Des Moines - 186
Orman Cr. - 64
Otter Cr. - 41
Otter Cr. - 150
Outlet Cr. - 127
Panther Cr. - 78
Pilot Cr. - 181
Plum Cr. - 172
Plunger Cr. - 66
Prairie Cr. - 120
Prairie Cr. - 151
Prairie Cr. - 155
Prairie Cr. - 179
Purgatory Cr. - 114
Raccoon R. - 70
Raccoon R. - 71
Raccoon R. - 72
Rock Cr. - 133
S. Br. Lizard Cr. - 159
S. Raccoon R. - 76
S. Raccoon R. - 77
Short Cr. - 109
Silver Cr. - 184
Skillet Cr. - 141
Slough Cr. - 131
Snake Cr. - 102
Soap Cr. - 16
Soap Cr. - 17
Soldier Cr. - 156
Soldier Cr. - 178
South Avery Cr. - 23
South Fork Clanton Cr. - 50
South Fork Middle R. - 53
South R. - 39
South Soap Cr. - 21
Spring Branch - 91
Spring Cr. - 160
Sugar Cr. - 13
Sugar Cr. - 75
Swan Lake Branch - 101
Tom Cr. - 62
Union Slough - 175
Union Slough Ditch - 189
Unnamed Cr. - 92
Unnamed Cr. - 113
Village Cr. - 22
W. Fk. Camp Cr. - 122
Walnut Cr. - 73
Walnut Cr. - 74
Welty Cr. - 52
West Buttrick Cr. - 106
West Fork Blue Earth R. - 188
West Panther Cr. - 79
White Breast Cr. - 33
White Breast Cr. - 34
White Fox Cr. - 146
Willey Branch - 90
Willow Cr. - 89
Wolf Cr. - 137

DES MOINES MAJOR RIVER - LOWER DES MOINES R. AND ITS TRIBUTARIES DES MOINES R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Des Moines R. 1. Mouth (Lee Co.) to confluence with the Raccoon River (includes Red Rock Reservoir)	X	X						
Des Moines R. 2. Ottumwa Municipal Water Works intake						X		
MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES								
Des Moines R. 3. Raccoon R. to Center St. Dam in Des Moines		X						
Des Moines R. 4. Center St. Dam in Des Moines to Hwy. I-80/I-35 (S17, T79N, R24W, Polk Co.)	X	X						
Des Moines R. 5. Des Moines Water Works intake, Prospect Park (NE 1/4, S28, T79N, R24W, Polk Co.)						X		
Des Moines R. 6. Hwy. I-80/I-35 to Saylorville Reservoir Dam		X						
Des Moines R. 7. Saylorville Reservoir Dam to Polk-Dallas co. line	X	X						
Des Moines R. 8. Saylorville Reservoir to Fraser Dam (S2, T84N, R27W, Boone Co.)		X						
Des Moines R. 9. Fraser Dam (Boone Co.) to W. line of S15, T88N, R28W, Webster Co.		X						X
Des Moines R. 10. West line of S15, T88N, R28W (Webster Co.) to dam of upper impoundment at Fort Dodge		X						
Des Moines R. 11. Upper impoundment at Fort Dodge	X	X						
Des Moines R. 12. Fort Dodge Upper impoundment to state line		X						
MAJOR RIVER - LOWER DES MOINES R. AND ITS TRIBUTARIES **SUGAR CR. AND ITS TRIBUTARIES**								
Sugar Cr. 13. Mouth (Lee Co.) to bridge crossing (S8, T67N, R6W, Lee Co.)			X					
LICK CR. AND ITS TRIBUTARIES								
Lick Cr. 14. Mouth (S19, T67N, R7W, Lee Co.) to confluence with an unnamed tributary (S32, T68N, R7W, Lee Co.)			X					
CHEQUEST CR. AND ITS TRIBUTARIES								
Chequest Cr. 15. Mouth (S27, T69N, R10W, Van Buren Co.) to confluence with North Chequest Cr. (S25, T70N, R13W, Wapello Co.)			X					

DES MOINES MAJOR RIVER - LOWER DES MOINES R. AND ITS TRIBUTARIES SOAP CR. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Soap Cr. 16. Mouth (S35, T71N, R12W, Jefferson Co.) to confluence with Little Soap Creek (S1, T70N, R13W, Davis Co.)		X						
Little Soap Cr. 18. Mouth (S1, T70N, R13W, Davis Co.) to confluence with an unnamed tributary (S21, T71N, R15W, Wapello Co.)			X					
Brush Cr. 19. Mouth (S3, T70N, R14W, Davis Co.) to confluence with an unnamed tributary (E 1/2, S25, T71N, R15W, Wapello Co.)			X					
Bear Cr. 20. Mouth (S19, T70N, R14W, Davis Co.) to confluence with an unnamed tributary (E 1/2, S4, T70N, R15W, Davis Co.)			X					
South Soap Cr. 21. Mouth (S21, T70N, R15W, Davis Co.) to Lake Dam (S29, T70N, R16W, Appanoose Co.)			X					
VILLAGE CR. AND ITS TRIBUTARIES Village Cr. 22. Mouth (S9, T71N, R13W, Wapello Co.) to confluence with Sandy Cr. (NW 1/4, S9, T71N, R14W, Wapello Co.)			X					
SOUTH AVERY CR. AND ITS TRIBUTARIES South Avery Cr. 23. Mouth (S31, T73N, R14W, Wapello Co.) to confluence with an unnamed tributary (NE 1/4, S15, T72N, R15W, Wapello Co.)			X					
MIDDLE AVERY CR. AND ITS TRIBUTARIES Middle Avery Cr. 24. Mouth (S25, T73N, R15W, Wapello Co.) to confluence with White Ash and Little Avery Crs. (W. line, S12, T72N, R16W, Monroe Co.)			X					
North Avery Cr. 25. Mouth (S34, T73N, R15W, Wapello Co.) to confluence with an unnamed tributary (Center, S34, T73N, R16W, Monroe Co.)			X					
MILLER CR. AND ITS TRIBUTARIES Miller Cr. 26. Mouth (Wapello Co.) to confluence with an unnamed tributary (Sec. 29, T73N, R16W, Monroe Co.)			X					
MUCHAKINOCK CR. AND ITS TRIBUTARIES Muchakinock Cr. 27. Confluence with Little Muchakinock Cr. (S34, T75N, R16W, Mahaska Co.) to confluence with an unnamed tributary (NW 1/4, SW 1/4, S27, T76N, R17W, Mahaska Co.)			X					
CEDAR CR. AND ITS TRIBUTARIES Cedar Cr. 28. Mouth (S33, T75N, R17W, Mahaska Co.) to confluence with North Cedar Cr. (NE 1/4, S15, T74N, R18W, Marion Co.)		X						
Cedar Cr. 29. Confluence with North Cedar Creek (NE 1/4, S15, T74N, R18W, Marion Co.) to confluence with Mormon Branch (S5, T71N, R18W, Monroe Co.)			X					

DES MOINES MAJOR RIVER - LOWER DES MOINES R. AND ITS TRIBUTARIES CEDAR CR. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
North Cedar Cr. 30. Mouth (S15, T74N, R18W, Marion Co.) to confluence with Sage Cr. (SE 1/4, S7, T73N, R19W, Monroe Co.)			X					
ENGLISH CR. AND ITS TRIBUTARIES English Cr. 31. Mouth (Marion Co.) to confluence with Long Branch (S16, T74N, R20W, Marion Co.)			X					
COMPETINE CR. AND ITS TRIBUTARIES Competine Cr. 32. Mouth (Marion Co.) to confluence with an unnamed tributary (S5, T75N, R19W, Marion Co.)			X					
WHITE BREAST CR. AND ITS TRIBUTARIES White Breast Cr. 33. Mouth (S10, T76N, R19W, Marion Co.) to confluence with Little White Breast Cr. (S11, T73N, R22W, Lucas Co.)		X						
White Breast Cr. 34. Confluence with Little White Breast Cr. (Lucas Co.) to confluence with an unnamed tributary (S4, T71N, R24W, Clarke Co.)			X					
Little White Breast Cr. 35. Mouth (Lucas Co.) to Ellis Lake (S27, T72N, R21W, Lucas Co.)			X					
Brush Cr. 36. Mouth (Lucas Co.) to confluence with an unnamed tributary (W 1/2, S21, T72N, R23W, Lucas Co.)			X					
CALHOUN CR. AND ITS TRIBUTARIES Calhoun Cr. 37. Mouth (Marion Co.) to confluence with Union Valley Cr. (S33, T78N, R20W, Jasper Co.)			X					
CAMP CR. AND ITS TRIBUTARIES Camp Cr. 38. Mouth (Jasper Co.) to confluence with an unnamed tributary (S14, T79N, R22W, Polk Co.)			X					
SOUTH R. AND ITS TRIBUTARIES South R. 39. Mouth (S12, T77N, R22W, Warren Co.) to confluence with Painter Cr. (SE 1/4, S13, T75N, R25W, Warren Co.)			X					
Coal Cr. 40. Mouth (Warren Co.) to confluence with Coon Cr. (S29, T76N, R21W, Marion Co.)			X					
Otter Cr. 41. Mouth (S34, T76N, R23W, Warren Co.) to confluence with Otter Cr. and South Otter Cr. (NW 1/4, S8, T73N, R23W, Lucas Co.)			X					
MUD CR. AND ITS TRIBUTARIES Mud Cr. 42. Mouth (Polk Co.) to confluence with an unnamed tributary (S36, T80N, R23W, Polk Co.)			X					
MIDDLE R. AND ITS TRIBUTARIES Middle R. 43. Mouth (Warren Co.) to confluence with Fletcher Br. (Madison Co.)		X						

DES MOINES MAJOR RIVER - LOWER DES MOINES R. AND ITS TRIBUTARIES MIDDLE RIVER AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Middle R. 44. Confluence with Flecher Branch (Madison Co.) to confluence with Bush Branch (S8, T75N, R29W, Madison Co.)		X						
Middle R. 45. Confluence with Bush Branch (S8, T75N, R29W, Madison Co.) to confluence with an unnamed tributary (NE 1/4, S17, T78N, R32W, Guthrie Co.)			X					
Cavitt Cr. 46. Mouth (Warren Co.) to confluence with an unnamed tributary (S13, T76N, R24W, Warren Co.)			X					
Clanton Cr. 47. Confluence with Jones Cr. (Madison Co.) to the confluence with the North Fork and South Fork Clanton Cr. (SW 1/4, S10, T74N, R27W, Madison Co.)			X					
Clanton Cr. 48. Mouth (N 1/2, S28, T76N, R25W, Warren Co.) to confluence with North & South Fork Clanton Cr.			X					
Jones Cr. 49. Mouth (Madison Co.) to confluence with an unnamed tributary (S28, T75N, R27W, Madison Co.)			X					
South Fork Clanton Cr. 50. Mouth (Madison Co.) to confluence with an unnamed tributary (NE 1/4 of NW 1/4, S36, T74N, R28W, Madison Co.)			X					
North Fork Clanton Cr. 51. Mouth (Madison Co.) to confluence with an unnamed tributary (S8/9, T74N, R28W, Madison Co.)			X					
Welty Cr. 52. Mouth (S14, T75N, R29W, Madison Co.) to confluence with Rocky Branch (SE 1/4, S22, T75N, R29W, Madison Co.)			X					
South Fork Middle R. 53. Mouth (S35, T78N, R32W, Guthrie Co.) to confluence with an unnamed tributary (S33, T78N, R32W, Guthrie Co.)			X					
NORTH R. AND ITS TRIBUTARIES								
North R. 54. Mouth (Polk Co.) to County Rd. R63 (S16, T77N, R24W, Warren Co.)		X						
North R. 55. County Rd. R63 (S16, T77N, R24W, Warren Co.) to confluence with Badger Cr. (S33, T77N, R25W, Warren Co.)		X						X
North R. 56. Confluence with Badger Cr. (S33, T77N, R25W, Warren Co.) to confluence with North Branch North R. (S33, T77N, R27W, Madison Co.)			X					X
North R. 57. Confluence with North Branch North R. (Madison Co.) to confluence with an unnamed tributary (S11, T77N, R31W, Adair Co.)			X					
Middle Cr. 58. Mouth (Warren Co.) to Lake Colechester Dam (NE 1/4, S1, T77N, R25W, Warren Co.)			X					

DES MOINES MAJOR RIVER - LOWER DES MOINES R. AND ITS TRIBUTARIES NORTH R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Badger Cr. 59. Mouth (Warren Co.) to Badger Lake Dam (NW 1/4, S13, T77N, R27W, Madison Co.)			X					
Cedar Cr. 60. Mouth (S9, T76N, R26W, Madison Co.) to confluence with an unnamed tributary (NW 1/4, S26, T76N, R28W Madison Co.)			X					
North Branch North R. 61. Mouth (Madison Co.) to confluence with an unnamed tributary (S5, T77N, R29W, Madison Co.)			X					
Tom Cr. 62. Mouth (Madison Co.) to confluence with an unnamed tributary (S26, T77N, R29W, Madison Co.)			X					
Jim Cr. 63. Mouth (Madison Co.) to confluence with an unnamed tributary (S15, T77N, R29W, Madison Co.)			X					
Orman Cr. 64. Mouth (S10, T76N, R28W, Madison Co.) to confluence with unnamed tributary (E 1/2, S4, T76N, R28W, Madison Co.)			X					
Howerdon Cr. 65. Mouth (S17, T76N, R28W, Madison Co.) to confluence with an unnamed tributary (SW 1/4, S25, T76N, R29W, Madison Co.)			X					
Plunger Cr. 66. Mouth (Adair Co.) to confluence with an unnamed tributary (S26, T77N, R30W, Adair Co.)			X					
FOURMILE CR. AND ITS TRIBUTARIES								
Fourmile Cr. 67. Mouth (Polk Co.) to Co. Rd. bridge (S18, T80N, R23W, Polk Co.)	X		X					
Fourmile Cr. 68. Co. Rd. bridge (S18, T80N, R23W, Polk Co.) to bridge crossing (N. line of S22, T81N, R24W, Polk Co.)			X					
Little Fourmile Cr. 69. Mouth (Polk Co.) to confluence with an unnamed tributary (S35, T79N, R23W, Polk Co.)			X					
MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES **RACCOON R. AND ITS TRIBUTARIES**								
Raccoon R. 70. Mouth (Polk Co.) to Polk-Dallas county line	X	X						
Raccoon R. 71. City of Des Moines Water Works intake						X		
Raccoon R. 72. Polk-Dallas co. line to confluence of N. Raccoon R. and S. Raccoon R.	X	X						X
Walnut Cr. 73. Mouth (S13, T78N, R25W, Polk Co.) to Interstate 35/80 (S33, T79N, R25W, Polk Co.)	X		X					
Walnut Cr. 74. Interstate 35/80 (S33, T79N, R25W, Polk Co.) to confluence with Little Walnut Cr. (SE 1/4, S24, T79N, R26W, Dallas Co.)			X					

DES MOINES **MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES** **RACCOON R. AND ITS TRIBUTARIES**	**A**	**B(WW)**	**B(LR)**	**B(LW)**	**B(CW)**	**C**	**HQ**	**HQR**
Sugar Cr. 75. Mouth (S26, T78N, R26W, Dallas Co.) to confluence with an unnamed tributary from the West (S8, T78N, R26W, Dallas Co.)			X					
S. Raccoon R. 76. Mouth (Dallas Co.) to confluence with Brushy Cr. (Guthrie Co.)		X						
S. Raccoon R. 77. Confluence with Brushy Cr. (S22, T79N, R31W, Guthrie Co.) to confluence with Frost Cr. (S18, T80N, R32W, Guthrie Co.)			X					
Panther Cr. 78. Mouth (S16, T78N, R28W, Dallas Co.) to confluence with West & East Panther Cr. (S16, T79N, R28W, Dallas Co.)			X					
West Panther Cr. 79. Mouth (S16, T79N, R28W, Dallas Co.) to confluence with an unnamed tributary (NW 1/4, S9, T79N, R28W, Dallas Co.)			X					
Bear Cr. 80. Mouth (S17, T78N, R28W, Dallas Co.) to confluence with an unnamed tributary (SW 1/4, S25, T78N, R29W, Dallas Co.)			X					
Middle Raccoon R. 81. Mouth (Dallas Co.) to Redfield Dam (S5, T78N, R29W, Dallas Co.)	X	X						
Middle Raccoon R. 82. Redfield Dam (Dallas Co.) to Lake Panorama Dam (S31, T80N, R30W, Guthrie Co.)	X	X						X
Middle Raccoon R. 83. City of Panora Water Works intakes						X		
Middle Raccoon R. 84. Lake Panorama	X	X						X
Middle Raccoon R. 85. Lake Panorama to confluence with Willey Branch (A26, T83N, R34W, Carroll Co.)	X	X						
Middle Raccoon R. 86. Confluence with Willey Branch (Carroll Co.) to confluence with an unnamed tributary (S8, T84N, R35W, Carroll Co.)			X					
Mosquito Cr. 87. Mouth (S34, T79N, R29W, Dallas Co.) to confluence with an unnamed tributary (S21, T81N, R30W, Guthrie Co.)			X					
Bay Branch 88. Mouth (S9, T79N, R30W, Guthrie Co.) to dam at Bay Branch Marsh (NW 1/4, S27, T80N, R30W, Guthrie Co.)			X					
Willow Cr. 89. Mouth (Guthrie Co.) to confluence with an unnamed tributary (SE 1/4, S30, T83N, R32W, Green Co.)			X					
Willey Branch 90. Mouth (Carroll Co.) to confluence with an unnamed tributary (S29, T83N, R34W, Carroll Co.)			X					

DES MOINES MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES RACCOON R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Spring Branch 91. Mouth (Carroll Co.) to confluence with an unnamed tributary (S16, T83N, R34W, Carroll Co.)			X					
Unnamed Cr. 92. Mouth (S29, T84N, R34W, Carroll Co.) to the northern road crossing on the section line between S24, T84N, R35W, and S19, T84N, R34W, Carroll Co.)			X					
Deer Cr. 93. Mouth (S15, T78N, R30W, Guthrie Co.) to confluence with an unnamed tributary (NE1/4, NE1/4 S19, T78N, R30W, Guthrie Co.)			X					
Brushy Creek 94. Mouth (Guthrie Co.) to confluence with an unnamed tributary (S6, T82N, R34W, Carroll Co.)			X					
Brushy Creek 95. Mouth (S22, T79N, R31W, Guthrie Co.) to confluence with an unnamed tributary (S6, T82N, R34W, Carroll Co.)			X					
N. Raccoon R. 96. Mouth (Dallas Co.) to Hwy. 286 (S17, T85N, R33W, Carroll Co.)	X	X						X
N. Raccoon R. 97. Hwy. 286 (Carroll Co.) to Sac. Co. Rd. M54 (S24, T88N, R36W, Sac Co.)	X	X						
North Raccoon River 98. Sac Co. Road M54 (S24, T88N, R36W, Sac Co.) to confluence with D.D. 101 (S36, T91N, R36W, Buena Vista Co.)		X						
N. Raccoon R. 99. Confluence with Drainage Ditch No. 101 (S36, T91N, R36W, Buena Vista Co.) to confluence with unnamed tributary (S4, T92N, R36W, Buena Vista Co.)			X					
Hickory Cr. 100. Mouth (S17, T79N, R27W, Dallas Co.) to confluence with unnamed tributary (westernmost tributary in W 1/2, S16, T79N, R27W, Dallas Co.)			X					
Swan Lake Branch 101. Mouth (S28, T81N, R28W, Dallas Co.) to west line S4, T80N, R28W, Dallas Co.			X					
Snake Cr. 102. Mouth (S2, T81N, R29W, Dallas Co.) to north line S26, T82N, R29W, Greene Co.			X					
Greenbrier Cr. 103. Mouth (S5, T81N, R29W, Dallas Co.) to west line S13, T82N, R31W, Greene Co.			X					
Dead Brier Cr. 104. Mouth (S36, T82N, R30W, Greene Co.) to confluence with an unnamed tributary (NE1/4, S26, T82N, R30W, Greene Co.)			X					
Buttrick Cr. 105. Mouth (S26, T83N, R30W, Greene Co.) to confluence with East & West Buttrick Cr. (SE 1/4, S25, T84N, R30W, Greene Co.)			X					

DES MOINES MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES RACCOON R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
West Buttrick Cr. 106. Mouth (S25, T84N, R30W, Greene Co.) to confluence with Ditch No. 52 (SE 1/4, S16, T86N, R30W, Webster Co.)			X					
East Buttrick Cr. 107. Mouth (S25, T84N, R30W, Greene Co.) to confluence with Lost Grove Cr. (SW 1/4, S4, T85N, R29W, Greene Co.)			X					
Hardin Cr. 108. Mouth (S23, T83N, R30W, Greene Co.) to confluence with Happy Run (SW 1/4, S22, T85N, R31W, Greene Co.)			X					
Short Cr. 109. Mouth (Greene Co.) to confluence with an unnamed tributary (S21, T84N, R31W, Greene Co.)			X					
Cedar Cr. 110. Mouth (S33, T85N, R32W, Greene Co.) to confluence with an unnamed tributary (NW 1/4, S15, T85N, R32W, Greene Co.)		X						
Cedar Cr. 111. Confluence with an unnamed tributary (NW 1/4, S15, T85N, R32W, Greene Co.) to confluence with East & West Cedar Crs. (S31, T87N, R31W, Calhoun Co.)			X					
East Cedar Cr. 112. Mouth (South Line, S31, T87N, R31W, Calhoun Co.) *to confluence with Welsh's Slough (Center, S3, T87N,* R31W, Calhoun Co.)			X					
Unnamed Cr. 113. Mouth (S18, T84N, R32W, Greene Co.) to confluence with an unnamed tributary (NE 1/4, S19, T84N, R32W, Greene Co.)			X					
Purgatory Cr. 114. Mouth (S11, T84N, R33W, Carroll Co.) to confluence with an unnamed tributary (NE 1/4, S17, T86N, R32W, Calhoun Co.)			X					
Marrowbone Cr. 115. Mouth (S17, T85N, R33W, Carroll Co.) to confluence with an unnamed tributary (NW 1/4, S17, T85N, R33W, Carroll Co.)			X					
Elk Run 116. Mouth (S7, T85N, R33W, Carroll Co.) to confluence with D.D. Nos. 72 & 81 (S5, T85N, R34W, Carroll Co.)			X					
Lake Cr. 117. Mouth (S23, T86N, R34W, Calhoun Co.) to East line S12, T86N, R34W, Calhoun Co.		X						
Lake Cr. 118. East line S12, T86N, R34W, Calhoun Co. to confluence with Ditch Nos. 65, and 9 & 13 (S29, T88N, R32W, Calhoun Co.)			X					
Ditch Nos. 9 & 13 119. Mouth (confluence with Ditch No. 65 in S29, T88N, R32W, Calhoun Co.) to the confluence with an unnamed tributary (SE 1/4, S8, T89N, R32W, Calhoun Co.)			X					

DES MOINES MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES RACCOON R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Prairie Cr. 120. Mouth (S16, T86N, R34W, Calhoun Co.) to confluence with Drainage Ditch No. 198 (S2, T86N, R34W, Calhoun Co.)			X					
Camp Cr. 121. Mouth (S7, T86N, R34W, Calhoun Co.) to confluence with unnamed tributary (S34, T88N, R34W, Calhoun Co.)			X					
W. Fk. Camp Cr. 122. Mouth (S8, T87N, R34W, Calhoun Co.) to confluence with Drainage Ditch No.1 (S10, T88N, R34W, Calhoun Co.)			X					
Indian Cr. 123. Mouth (S24, T87N, R36W, Sac Co.) to confluence with an unnamed tributary (N 1/2, SW 1/4, S20, T87N, R36W, Sac Co.)			X					
Cedar Cr. 124. Mouth (S25, T88N, R36W, Sac Co.) to confluence with Little Cedar Cr. (S15, T90N, R34W, Pocahontas Co.)			X					
Little Cedar Cr. 125. Mouth (S15, T90N, R34W, Pocahontas Co.) to confluence with unnamed tributary (S19, T91N, R34W, Pocahontas Co.)			X					
Buck Run 126. Mouth (SE 1/4, S11, T89N, R36W, Sac Co.) to confluence with an unnamed tributary (E 1/2, S9, T89N, R36W, Sac Co.)			X					
Outlet Cr. 127. Mouth (Buena Vista Co.) to bridge crossing at (S26/27, T90N, R36W, Buena Vista Co.)			X					
BEAVER CR. AND ITS TRIBUTARIES Beaver Cr. 128. Mouth (S17, T79N, R24W, Polk Co.) to confluence with an unnamed tributary (S29, T84N, R28W, Boone Co.)			X					
Little Beaver Cr. 129. Mouth (S35, T80N, R25W, Polk Co.) to confluence with an unnamed tributary (SW 1/4, SW 1/4, S29, T80N, R25W, Polk Co.)			X					
Little Beaver Cr. 130. Mouth (S14, T81N, R27W, Dallas Co.) to confluence with an unnamed tributary (SE 1/4, SE 1/4, S29, T82N, R27W, Boone Co.)			X					
Slough Cr. 131. Mouth (S16, T81N, R27W, Dallas Co.) to confluence with an unnamed tributary (NW 1/4, S21, T81N, R27W, Dallas Co.)			X					
Middle Beaver Cr. 132. Mouth (S21, T83N, R28W, Boone Co.) to Hwy. 30 (North line, S4, T83N, R28W, Boone Co.)			X					
ROCK CR. AND ITS TRIBUTARIES Rock Cr. 133. Mouth (S32, T80N, R24W, Polk Co. to Hwy. 415 bridge crossing (S21, T80N, R24W, Polk Co.)			X					

DES MOINES MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES BIG CREEK (AKA BIG CR. LAKE OUTLET) AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Big Creek (aka Big Cr. Lake Outlet) 134. Mouth (Polk Co.) to Big Creek Lake Dam (SW 1/4, S26, T81N, R25W, Polk Co.)		X						
Big Creek (aka Big Cr. Lake Outlet) 135. Big Cr. Lake	X	X						
Big Cr. 136. Upper end of Big Creek Lake (Polk Co.) to confluence with an unnamed tributary (SE 1/4, S33, T83N, R25W, Boone Co.)			X					
Wolf Cr. 137. Mouth (S36, T81N, R25W, Polk Co.) to North line, S25, T81N, R25W, Polk Co.			X					
BEAR CR. AND ITS TRIBUTARIES Bear Cr. 138. Mouth (S29, T83N, R26W, Boone Co.) to confluence with an unnamed tributary (SE 1/4, S24, T83N, R27W, Boone Co.)			X					
HONEY CR. AND ITS TRIBUTARIES Honey Cr. 139. Mouth (Boone Co.) to bridge crossing at (NW 1/4, S33, T84N, R26W, Boone Co.)		X						
BLUFF CR. AND ITS TRIBUTARIES Bluff Cr. 140. Mouth (S22, T84N, R27W, Boone Co.) to dam/ spillway at Don Williams Lake (NE 1/4, SW 1/4, S5, T84N, R27W, Boone Co.)			X					
SKILLET CR. AND ITS TRIBUTARIES Skillet Cr. 141. Mouth (S16, T86N, R27W, Webster Co.) to confluence with an unnamed tributary (NW 1/4, SE 1/4, S14, T86N, R28W, Webster Co.)			X					
BOONE R. AND ITS TRIBUTARIES Boone R. 142. Mouth (Webster Co.) to State Hwy. 17 (S18, T88N, R25W, Hamilton Co.)	X	X						X
Boone R. 143. State Hwy. 17 to confluence with Brewers Creek (Hamilton Co.)		X						X
Boone R. 144. Confluence with Brewers Creek (Hamilton Co.) to confluence with Middle Branch Boone R. (Wright Co.)		X						
Boone R. 145. Confluence with Middle Branch Boone R. (Wright Co.) to confluence with Drainage Ditch No. 10 (S29, T95N, R26W, Hancock Co.)			X					
White Fox Cr. 146. Mouth (S33, T89N, R25W, Hamilton Co.) to confluence with an unnamed tributary (E 1/2 of the SE 1/4 of S36, T91N, R25W, Wright Co.)			X					
Buck Cr. 147. Mouth (S28, T89N, R25W, Hamilton Co.) to confluence with Drainage Ditch No. 144 (S11, T88N, R25W, Hamilton Co.)			X					

DES MOINES MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES BOONE R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Eagle Cr. 148. Mouth (S6, T89N, R25W, Hamilton Co.) to confluence with Little Eagle Cr. (S9, T91N, R25W, Wright Co.)			X					
D.D. 94 149. Mouth (Wright Co.) to West line of S3, T90N, R26W, Wright Co.		X						
Otter Cr. 150. Mouth (Wright Co.) to confluence with West Otter Cr. (S31, T93N, R25W, Wright Co.)		X						
Prairie Cr. 151. Mouth (S30, T93N, R26W, Wright Co.) to confluence with D.D. No. 116 (S24, T94N, R28W, Kossuth Co.)			X					
Middle Branch Boone R. 152. Mouth (Hancock Co.) to confluence with an unnamed tributary (S31, T95N, R25W, Hancock Co.)		X						
BRUSHY CR. AND ITS TRIBUTARIES								
Brushy Cr. 153. Mouth (S15, T87N, R27W, Webster Co.) to Brushy Creek Lake Dam (S34, T88N, R27W, Webster Co.)			X					
Brushy Cr. 154. Upper extent of Brushy Creek Lake (W. line of S16, T88N, R27W) to confluence with unnamed tributary (SE 1/4, S34, T89N, R27W, Webster Co.)			X					
PRAIRIE CR. AND ITS TRIBUTARIES								
Prairie Cr. 155. Mouth (S35, T88N, R28W, Webster Co.) to confluence with D.D. No. 29 (S25, T88N, R29W, Webster Co.)			X					
SOLDIER CR. AND ITS TRIBUTARIES								
Soldier Cr. 156. Mouth (S19, T89N, R28W, Webster Co.) to confluence with unnamed tributary (S26, T90N, R28W, Webster Co.)			X					
LIZARD CR. AND ITS TRIBUTARIES								
Lizard Cr. 157. Mouth (S19, T89N, R28W, Webster Co.) to confluence with unnamed tributary (N 1/2, S31, T90N, R30W, Webster Co.)		X						
Lizard Cr. 158. Confluence with unnamed tributary (N 1/2, S31, T90N, R30W, Webster Co.) to confluence with Drainage Ditch No. 164 (S31, T91N, R31W, Pocahontas Co.)			X					
S. Br. Lizard Cr. 159. Mouth (S23, T89N, R29W, Webster Co.) to confluence with unnamed tributary (S25, T90N, R32W, Pocahontas Co.)			X					
Spring Cr. 160. Mouth (S33, T89N, R29W, Webster Co.) to confluence with Prairie Creek (S14, T88N, R30W, Webster Co.)			X					
N. Br. Lizard Cr. 161. Mouth (S2, T91N, R31W, Pocahontas Co.) to confluence with Drainage Ditch No. 169 (S6, T91N, R31W, Pocahontas Co.)			X					

DES MOINES MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES BADGER CR. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Badger Cr. 162. Mouth (S30, T90N, R28W, Webster Co.) to Badger Lake Dam (S19, T90N, R28W, Webster Co.)			X					
DEER CR. AND ITS TRIBUTARIES Deer Cr. 163. Mouth (S13, T90N, R29W, Webster Co.) to confluence with unnamed tributary (S16, T90N, R29W, Webster Co.)			X					
BEAVER CR. AND ITS TRIBUTARIES Beaver Cr. 164. Mouth (S32, T91N, R28W, Humboldt Co.) to confluence with unnamed tributary (S28, T91N, R28W, Humboldt Co.)			X					
E. FK. DES MOINES R. AND ITS TRIBUTARIES E. Fk. Des Moines R. 165. Mouth (Humboldt Co.) to Divine bridge access Hwy. 169 (S26, T94N, R29W, Kossuth Co.)	X	X						X
E. Fk. Des Moines R. 166. Divine bridge access Hwy. 169 (S26, T94N, R29W, Kossuth Co.) to County Rd. B63 (S23, T94N, R29W, Kossuth Co.)		X						X
E. Fk. Des Moines R. 167. County Rd. B63 (Kossuth Co.) to confluence with Buffalo Cr. (Kossuth Co.)		X						
East Fork Des Moines R. 168. Confluence with Buffalo Cr. (S20, T97N, R28W, Kossuth Co.) to outlet control structure Tuttle Lake (aka Okamanpeedan Lake) (S14, T100N, R32W, Emmet Co.)		X						
Bloody Run 169. Mouth (S33, T93N, R28W, Humboldt Co.) to confluence with unnamed tributary (S1, T92N, R29W, Humboldt Co.)			X					
Lotts Cr. 170. Mouth (S17, T93N, R28W, Humboldt Co.) to confluence with D.D. No. 79 (SE 1/4, S15, T94N, R30W, Kossuth Co.)			X					
Black Cat Cr. 171. Mouth (S24, T96N, R29W, Kossuth Co.) to North line (S5, T97N, R30W, Kossuth Co.)			X					
Plum Cr. 172. Mouth (S17, T96N, R28W, Kossuth Co.) to confluence with an unnamed tributary (S16, T96N, R27W, Kossuth Co.)			X					
Lindsey Cr. 173. Mouth (S28, T96N, R28W, Kossuth Co.) to confluence with an unnamed tributary (aka D.D. No. 36) (S30, T97N, R27W, Kossuth Co.)			X					
Buffalo Cr. 174. Mouth (S20, T97N, R28W, Kossuth Co.) to confluence with D.D. No. 48 (S33, T98N, R26W, Winnebago Co.)			X					
Union Slough 175. Mouth (S9, T97N, R28W, Kossuth Co.) to outlet control structure (aka Des Moines R./Blue Earth R. basin divide) (N 1/2, S14, T98N, R28W, Kossuth Co.)				X				

DES MOINES MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES E. FK. DES MOINES R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
North Buffalo Cr. (aka Little Buffalo Cr.) 176. Mouth (S4, T97N, R27W, Kossuth Co.) to confluence with an unnamed tributary (S5, T98N, R26W, Winnebago Co.)			X					
Mud Cr. 177. Mouth (S1, T97N, R29W, Kossuth Co.) to confluence with an unnamed tributary (North line S3/4, T98N, R29W, Kossuth Co.)			X					
Soldier Cr. 178. Mouth (S36, T100N, R32W, Emmet Co.) to confluence with D.D. No. 4 (S27, T100N, R32W, Emmet Co.)			X					
INDIAN CR. AND ITS TRIBUTARIES Prairie Cr. (aka Ditch No. 61) 179. Mouth (S1, T93N, R31W, Pocahontas Co.) to confluence with an unnamed tributary (S13, T94N, R31W, Palo Alto Co.)			X					
Indian Cr. 180. Mouth (S24, T91N, R29W, Humboldt Co.) to confluence with Drainage Ditch No. 20 (S21, T91N, R29W, Humboldt Co.)			X					
PILOT CR. AND ITS TRIBUTARIES Pilot Cr. 181. Mouth (S1, T92N, R31W, Pocahontas Co.) to confluence with an unnamed tributary (SW 1/4, S16, T93N, R32W, Pocahontas Co.)			X					
CYLINDER CR. AND ITS TRIBUTARIES Cylinder Cr. 182. Mouth (NW 1/4, S28, T94N, R31W, Palo Alto Co.) to confluence with D.D. No. 15 (NW 1/4, S18, T96N, R31W, Palo Alto Co.)			X					
BEAVER CR. AND ITS TRIBUTARIES Beaver Cr. 183. Mouth (S36, T93N, R31W, Pocahontas Co.) to confluence with an unnamed tributary (S12, T93N, R32W, Pocahontas Co.)			X					
SILVER CR. AND ITS TRIBUTARIES Silver Cr. 184. Mouth (S35, T96N, R33W, Palo Alto Co.) to confluence with D.D. No. 62 (S23, T95N, R34W, Palo Alto Co.)			X					
JACK CR. AND ITS TRIBUTARIES Jack Cr. 185. Mouth (S35, T97N, R33W, Palo Alto Co.) to Swan Lake outlet structure (S29, T99N, R32W, Emmet Co.)			X					
OLD CHANNEL - DES MOINES R. AND ITS TRIBUTARIES Old Channel - Des Moines R. 186. Mouth (S26, T95N, R32W, Palo Alto Co.) to confluence with Ditch No. 41 (S29, T95N, R32W, Palo Alto Co.)		X						
BLUE EARTH R. AND ITS TRIBUTARIES Blue Earth R. (aka Middle Branch Blue Earth R.) 187. Iowa-Minnesota state line (S12, T100N, R28W, Kossuth Co.) to confluence with an unnamed tributary (S9, T99N, R27W, Kossuth Co.)			X					

DES MOINES MAJOR RIVER - UPPER DES MOINES R. AND ITS TRIBUTARIES BLUE EARTH R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
West Fork Blue Earth R. (aka West Branch Blue Earth R.) 188. Iowa-Minnesota state line (S9, T100N, R28W, Kossuth Co.) to confluence with an unnamed tributary (S30, T100N, R28W, Kossuth Co.)			X					
Union Slough Ditch (aka Union Slough Outlet) 189. Mouth (S9, T100N, R28W, Kossuth Co.) to outlet control structure (aka Des Moines R./Blue Earth R. basin divide) (N 1/2, S14, T98N, R28W, Kossuth Co.)			X					

SKUNK RIVER BASIN

The streams or stream segments named below in alphabetical order are referenced within the Water Use Designations for the Skunk River Basin. Reference numbers provided in the alphabetical list correspond to numbered stream segments in the Water Use Designations.

Ballard Cr. - 46
Bear Cr. - 49
Benjamin Cr. - 39
Big Cr. - 16
Big Cr. - 17
Big Slough - 8
Brush Cr. - 18
Buckley Cr. - 37
Cedar Cr. - 22
Cedar Cr. - 23
Cedar Cr. - 54
Cherry Cr. - 38
Clear Cr. - 41
Competine Cr. - 27
Crooked Cr. - 28
Crow Cr. - 25
Dye Cr. - 44
E. Branch Indian Cr. - 43
East Fork Crooked Cr. - 29
Fish Cr. - 20
Indian Cr. - 40
Long Cr. - 14
Long Dick Cr. - 50
Lynn Cr. - 19
Middle Cr. - 56
Mississippi R. - 1
Mississippi R. - 2
Mississippi R. - 3
Mud Cr. - 15
N. Skunk R. - 51
N. Skunk R. - 52
N. Skunk R. - 53
Oakland Mills Impoundment - 10
Old South Skunk River Ch - 45
Pitman Cr. - 6
Rock Cr. - 24
Rock Cr. - 55
Rock Cr. - 58
Rock Cr. - 26
S. Skunk R. - 31
S. Skunk R. - 32
S. Skunk R. - 33
S. Skunk R. - 34
Skunk R. - 9
Skunk R. - 11
Skunk R. - 12
Skunk R. - 13
Snipe Cr. - 59
South Skunk R. - 35
South Skunk R. - 36
Squaw Cr. - 48
Sugar Cr. - 5
Sugar Cr. - 57
Unnamed Cr. - 4
W. Branch Indian Cr. - 42
W. Fk Crooked Cr. - 30
Walnut Cr. - 47
West Branch Sugar Cr. - 7
Wolf Cr. - 21

SKUNK MAJOR RIVER - MISSISSIPPI R. AND ITS TRIBUTARIES MISSISSIPPI R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Mississippi R. 1. Iowa-Missouri state line to confluence with the Skunk R.	X	X						
Mississippi R. 2. Keokuk Municipal Water Works intakes						X		
Mississippi R. 3. Fort Madison Municipal Water Works intakes						X		
UNNAMED CR. AND ITS TRIBUTARIES								
Unnamed Cr. (aka Labalees Cr.) 4. Mouth (S1, T65N, R5W, Lee Co.) to confluence with an unnamed tributary (E 1/2, S35, T66N, R5W, Lee Co.)			X					

SKUNK **MAJOR RIVER - MISSISSIPPI R. AND ITS TRIBUTARIES** **SUGAR CR. AND ITS TRIBUTARIES**	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Sugar Cr. 5. Mouth (S23, T67N, R5W, Lee Co.) to confluence with an unnamed tributary (S 1/2, S16, T69N, R6W, Lee Co.)			X					
Pitman Cr. 6. Mouth (S29/30 line, T68N, R5W, Lee Co.) to confluence with an unnamed tributary (S21, T68N, R5W, Lee Co.)			X					
West Branch Sugar Cr. 7. Mouth (S11/14 line, T68N, R6W, Lee Co.) to confluence with an unnamed tributary (S3, T68N, R6W, Lee Co.)			X					
BIG SLOUGH AND ITS TRIBUTARIES								
Big Slough 8. Mouth (S24, T68N, R3W, Lee Co.) to confluence with an unnamed tributary (S18, T68N, R2W, Lee Co.)		X						
SKUNK R. AND ITS TRIBUTARIES								
Skunk R. 9. Mouth to Oakland Mills Dam Skunk R.		X						
Oakland Mills Impoundment 10. Dam to N line of S14, T71N, R7W, Henry Co.	X	X						
Skunk R. 11. City of Mt. Pleasant Water Works intake						X		
Skunk R. 12. Oakland Mills Impoundment to Henry Co. Rd. (S3, T71, R7W)		X						
Skunk R. 13. Henry Co. Rd. (S3, T73N, R7W) to confluence of N. Skunk R. and S. Skunk R.		X						X
Long Cr. 14. Mouth (Des Moines Co.) to confluence with an unnamed tributary (S3, T69N, R4W, Des Moines Co.)			X					
Mud Cr. 15. Mouth (S34, T70N, R5W, Henry Co.) to confluence with an unnamed tributary (S12, T70N, R5W, Henry Co.)			X					
Big Cr. 16. Mouth (Henry Co.) to confluence with Saunders Branch (S17, T71N, R6W, Henry Co.)		X						
Big Cr. 17. Confluence with Saunders Branch (Henry Co.) to confluence with Lawrence Creek (S5, T71N, R5W, Henry Co.)			X					
Brush Cr. 18. Mouth (Henry Co.) to confluence with an unnamed tributary (S32, T71N, R5W, Henry Co.)			X					
Lynn Cr. 19. Mouth (Henry Co.) to confluence with an unnamed tributary (S7, T72N, R6W, Henry Co.)			X					
Fish Cr. 20. Mouth (S23, T70N, R6W, Henry Co.) to confluence with an unnamed tributary (S16, T70N, R6W, Henry Co.)			X					

SKUNK **MAJOR RIVER - MISSISSIPPI R. AND ITS TRIBUTARIES** **SKUNK R. AND ITS TRIBUTARIES**	**A**	**B(WW)**	**B(LR)**	**B(LW)**	**B(CW)**	**C**	**HQ**	**HQR**
Wolf Cr. 21. Mouth (S8, T71N, R7W, Henry Co.) to confluence with an unnamed tributary (S1, T71N, R8W, Jefferson Co.)			X					
Cedar Cr. 22. Mouth (Henry Co.) to confluence with Little Cedar Cr. (S17, T70N, R7W, Henry Co.)		X						
Cedar Cr. 23. Confluence with Little Cedar Cr. (Sec. 17, T70N, R7W, Henry Co.) to confluence with an unnamed tributary (NW 1/4, of the NE 1/4, S24, T74N, R15W, Mahaska Co.)			X					
Rock Cr. 24. Mouth (Jefferson Co.) to confluence with Jones Br. (Sec. 29, T71N, R8W, Jefferson Co.)			X					
Crow Cr. 25. Mouth (Jefferson Co.) to confluence with an unnamed tributary (NW 1/4 of SW 1/4, S31, T72N, R9W, Jefferson Co.)			X					
Rock Cr. 26. Mouth (S34, T72N, R11W, Jefferson Co.) to confluence with an unnamed tributary (NE1/4, S5, T71N, R11W, Jefferson Co.)			X					
Competine Cr. 27. Mouth (Jefferson Co.) to confluence with an unnamed tributary (S15, T73N, R12W, Wapello Co.)			X					
Crooked Cr. 28. Mouth (S1, T73N, R8W, Jefferson Co.) to confluence with East and West Fork Crooked Cr. (S24, T74N, R7W, Washington Co.)			X					
East Fork Crooked Cr. 29. Mouth (S24, T74N, R7W, Washington Co.) to confluence with Phillips Creek (S8, T73N, R5W, Henry Co.)			X					
W. Fk. Crooked Cr. 30. Mouth (Washington Co.) to confluence with an unnamed tributary (SW 1/4, S21, T76N, R9W, Washington Co.)			X					
S. Skunk R. 31. Mouth (Keokuk Co.) to Hwy. 21 (S34, T75N, R13W, (Keokuk Co.)		X						X
S. Skunk R. 32. Hwy. 21 (Keokuk Co.) to confluence with Indian Cr. (Jasper Co.)		X						
S. Skunk R. 33. At Oskaloosa						X		
S. Skunk R. 34. Confluence with Indian Creek (Jasper Co.) to Ames Water Works Dam (S36, T84N, R24W, Story Co.)			X					
South Skunk R. 35. Ames Waterworks Dam (S36, T84N, R24W, Story Co.) to North line S6, T85N, R23W, Story Co.		X						
South Skunk R. 36. North line S6, T85N, R23W, Story Co. to confluence with D.D. No. 71 (S11, T86N, R24W, Hamilton Co.)			X					

SKUNK MAJOR RIVER - MISSISSIPPI R. AND ITS TRIBUTARIES SKUNK R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
Buckley Cr. 37. Mouth (S27, T77N, R17W, Mahaska Co.) to confluence with The Middle Br. Buckley Cr. (S9, T77N, R17W, Mahaska Co.)			X					
Cherry Cr. 38. Mouth (Jasper Co.) to confluence with Benjamin Cr. (S20, T80N, R19W, Jasper Co.)			X					
Benjamin Cr. 39. Mouth (Jasper Co.) to confluence with an unnamed tributary (NE 1/4, S21, T80N, R19W, Jasper Co.)			X					
Indian Cr. 40. Mouth (S32, T80N, R20W, Jasper Co.) to confluence with East and West Branch Indian Crs. (S16, T82N, R22W, Story Co.)			X					
Clear Cr. 41. Mouth (S2, T80N, R21W, Jasper Co.) to confluence with an unnamed tributary (S 1/2, SW 1/4, S28, T82N, R20W, Marshall Co.)			X					
W. Branch Indian Cr. 42. Mouth (S16, T82N, R22W, Story Co.) to confluence with an unnamed tributary (S1, T83N, R23W, Story Co.)			X					
E. Branch Indian Cr. 43. Mouth (S16, T82N, R22W, Story Co.) to confluence with an unnamed tributary (S34, T85N, R22W, Story Co.)			X					
Dye Cr. 44. Mouth (S14, T83N, R22W, Story Co. to confluence with unnamed tributary (NW 1/4, S7, T83N, R21W, Story Co.)			X					
Old South Skunk River Channel 45. East line S31, T81N, R22W, Polk Co. to South line S33/34, T81N, R22W, Polk Co.				X				
Ballard Cr. 46. Mouth (Story Co.) to confluence with an unnamed tributary (S15, T82N, R24W, Story Co.)			X					
Walnut Cr. 47. Mouth (S5, T82N, R23W, Story Co.) to confluence with an unnamed tributary (SE 1/4, S34, T83N, R24W, Story Co.)			X					
Squaw Cr. 48. Mouth (S12, T83N, R24W, Story Co.) to confluence with an unnamed tributary (NW 1/4, S9, T85N, R25W, Boone Co.)			X					
Bear Cr. 49. Mouth (Story Co.) to N. line of Sec. 32, T85N, R23W, Story Co.			X					
Long Dick Cr. 50. Mouth (S18, T85N, R23W, Story Co.) to bridge crossing (North line S34, T86N, R23W, Hamilton Co.)			X					
N. Skunk R. 51. Mouth (S5, T74N, R10W, Keokuk Co.) to confluence with Cedar Cr. (S15, T75N, R12W, Keokuk Co.)		X						X

SKUNK MAJOR RIVER - MISSISSIPPI R. AND ITS TRIBUTARIES SKUNK R. AND ITS TRIBUTARIES	A	B(WW)	B(LR)	B(LW)	B(CW)	C	HQ	HQR
N. Skunk R. 52. Confluence with Cedar Cr. (S15, T75N, R12W, Keokuk Co.) to Poweshiek-Mahaska co. line			X					X
N. Skunk R. 53. Poweshiek-Mahaska co. line to confluence with Snipe Cr. (S22, T81N, R19W, Jasper Co.)			X					
Cedar Cr. 54. Mouth (S15, T75N, R12W, Keokuk Co.) to confluence with an unnamed tributary (S34, T76N, R13W, Keokuk Co.)			X					
Rock Cr. 55. Mouth (S9, T75N, R12W, Keokuk Co.) to confluence with unnamed tributary (NE 1/4, S34, T76N, R12W, Keokuk Co.)			X					
Middle Cr. 56. Mouth (S35, T76N, R14W, Mahaska Co.) to Hwy. 146 road crossing at S1, T76N, R16W, Mahaska Co.)			X					
Sugar Cr. 57. Mouth (Poweshiek Co.) to confluence with an unnamed tributary (SW 1/4, Sec. 24, T80N, R17W, Jasper Co.)			X					
Rock Cr. 58. Mouth (S5, T79N, R17W, Jasper Co.) to Rock Creek Lake Dam (S17, T80N, R17W, Jasper Co.)			X					
Snipe Cr. 59. Mouth (S22, T81N, R19W, Jasper Co.) to confluence with Little Snipe Cr. (S14, T81N, R19W, Jasper Co.)			X					

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Revised March 20, 1990

Modifications to Chapter IV - Basin Plan Support Document

The following is a brief description of the significant changes made in Chapter IV and the reasons for these changes. The changes begin on page 40 to the end of the document. There has not been any changes made to the water quality models or their procedures sections.

I. Modifications to the Wasteload Allocation Procedures.

The 1990 Water Quality Standards revisions have required numerous modifications to the previous wasteload allocation procedures. They include the introduction of the two number criteria, ammonia nitrogen criteria being a function of pH and temperature, more specific physical limitation to the mixing zone, the introduction of a zone of initial dilution, and a permit derivation procedure. These modifications will be discussed below.

A. Two Number Criteria. The new concept of using the two number criteria for toxic pollutants and total residual chlorine represents the instream water quality values necessary to protect aquatic species from both acute and chronic toxicity in designated streams, rivers, lakes, and wetlands. Therefore, the wasteload allocation procedure will now calculate two different values, one for meeting the acute criterion and the other meeting the chronic criterion.

B. Physical Limitations of the Mixing Zone. The standards establish the physical dimensions and flow restrictions of the regulatory mixing zone. The specified length limitations of the mixing zone, the actual low stream flow, and associated width, contained at the boundary of the most restrictive length limitation provides the amount of diluting flow allowed in the wasteload allocation procedures. The chronic criteria contained in the water quality standards will be met at the boundary of the mixing zone through dilution with the available stream flow in the mixing zone.

For toxic parameters (Table 1 of the Water Quality Standards), the mixing zone shall not exceed 25% of the 7Q10 stream flow or protected flow. While for ammonia nitrogen (Table 3 of the Standards) the mixing zone flow is restricted based on the facilities dilution ratio. Dilution ration is the ratio of the 7Q10 stream flow or protected flow to the effluent design flow.

C. Zone of Initial Dilution. This new concept represents a small area within the mixing zone where dilution is allowed such that the acute criteria is met at the defined boundary of this zone of initial dilution. The dimension and stream flow of this zone is limited to 10% of the mixing zone for toxic parameters. For ammonia nitrogen the dimension and stream flow of this zone is limited to 10% of the mixing zone for facilities with a dilution ratio of greater than 2 to 1. For facilities with a dilution ratio equal to or less than 2 to 1, the dimension and stream flow of this zone is limited to 5% of the mixing zone.

D. Ammonia Nitrogen Criteria. The revised ammonia criteria reflects the above mentioned two number criteria approach being pH and temperature dependent. This dependency requires that the wasteload allocation procedures first incorporate the pH and temperature conditions occurring at low stream flow periods in selecting the appropriate acute and chronic criteria. The wasteload allocations procedures then is calculated following the same procedure as for other toxics.

E. Prevention of Toxic Conditions in General Classified Streams. The 1989 water quality standards revisions further clarify the 'free from' statement applicable to all streams. This provisions states that all waters shall be free from substances attributable to wastewater discharges or agricultural practices in concentrations or combinations which are acutely toxic to humans, animal, or plant life. The wasteload allocation procedure to implement this provision will closely follow the existing approach by considering the laboratory toxicity data (96hr.LC_{50}) of the most sensitive aquatic specie present in the receiving stream.

Typically a resident fish (minnow) species is selected.

II. Permit Derivation Procedure.

A new provision of the water quality standards requires that the wasteload allocation value, calculated to protect water quality standards, be mathematically modified prior to being included in NPDES permits as effluent limits. The mathematical modifications, based on EPA guidance documents, reflect the uncertainty of effluent sampling, analytical precision, and effluent monitoring frequency. This procedure, discussed in this Support Document, will only be applied to parameters warranting water quality based permit limits, not to technology based limits, such as secondary treatment or BAT/BPT.

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Chapter IV - Segment Analysis Methodology & Wasteload Allocations

The ability of a stream to maintain an acceptable dissolved oxygen (DO) concentration is an important consideration in determining its capacity to assimilate wastewater discharges. Microbial oxidation of organic and certain inorganic matter present in wastewater uses dissolved oxygen. Oxygen supplied principally by reaeration from the atmosphere will replace any dissolved oxygen lost through oxidation processes. If, however, the rate of oxygen use exceeds the rate of reaeration, the DO concentration may decrease below minimum allowable standards.

To predict the variation in DO, as well as ammonia concentration in streams, several computer-based mathematical models have been used. The two models presently utilized are the Modified Iowa and the more sophisticated QUAL-II program. Each of these are described later in this chapter. Input data for the models were developed from existing technical information and recent field investigations of selected streams. When sufficient data were not available, conservative assumptions have been made that tend to assure a high degree of protection for water quality without necessitating unrealistically stringent effluent limitations. Recent water quality sampling has helped to demonstrate the reliability of particular constants and assumptions used, and improve the validity of the models. It is felt that with available data, a reasonably accurate prediction of the impact of different wastewater loads or treatment arrangements upon the DO and ammonia concentrations may be performed, and that determination of wastewater discharges that will not result in violation of water quality standards is possible.

THEORY AND METHODOLOGY

Modeling Theory

Dissolved oxygen concentrations in streams are controlled by many factors including atmospheric reaeration, biochemical oxygen demands (carbonaceous and nitrogenous), algal photosynthesis and respiration, benthal oxygen demands, temperature, and the physical characteristics of the stream. Many of these factors are difficult, if not impossible, to accurately assess. As a result of this difficulty, limitations on the use of these controlling factors are discussed below.

Photosynthesis can produce large quantities of oxygen during the day if algae are present in the stream. Conversely, at night algal respiration creates an oxygen demand. Research efforts have attempted to fit harmonic functions to this phenomenon, but with limited success. Specific allowance for diurnal fluctuations in oxygen levels is included in the QUAL-II computer model only.

Benthal oxygen demands result from anaerobic decomposition of settled organic material at the bottom of the stream. These reactions release carbonaceous and nitrogenous organic materials which create biochemical oxygen demands. The inclusion of benthal oxygen demands in the QUAL-II model requires extensive field surveys to determine the real extent of sludge deposits within a stream and coefficients that describe the release into the water. Since the impact is minor in most instances and no data are available to accurately describe sludge deposition areas, no special allowance for benthal oxygen demands is included in the Modified Iowa model formulation. However, QUAL-II has provision for benthic activities providing sufficient field data is available to calibrate and verify the rate constants.

A complete mathematical model to describe DO concentrations within the stream would include all significant factors. Natural systems cannot presently be expressed mathematically with absolute certainty, but reasonably accurate predictions can be made through realistic assumptions concerning the reaeration phenomenon and deoxygenation caused by carbonaceous and nitrogenous biochemical oxygen demands (BOD). Specific values obtained in detailed field investigations from other locations, with particular emphasis placed upon data collected in Iowa, provide the only basis for defining ranges of coefficient values being incorporated in the water quality models today. The continued effort towards the collection of water quality data at low flow conditions will aid in defining the above coefficient ranges used in the future.

Nitrogenous BOD is due to the oxidation of ammonia to nitrates by certain species of bacteria. This oxidation process is called nitrification. Nitrification is a two-step process whereby a specific bacterial species oxidizes ammonia to nitrite and a different bacterial species oxidizes the nitrite to nitrate. Theoretically, approximately 4.5 mg/l of oxygen are required to oxidize 1.0 mg/l of ammonia (expressed as nitrogen) to nitrate. This theoretical value may conservatively over estimate the oxygen demand of NH_3 as the nitrifiers obtain oxygen from inorganic carbon sources during combined energy and synthesis reactions. Actual values obtained have varied between 3.8 and 4.5 mg/l of oxygen per mg/l of NH_3-N. The Modified Iowa model uses 4.33 as the ratio of nitrogenous BOD to ammonia nitrogen. Since secondary wastewater treatment plant effluents quite commonly contain ammonia nitrogen levels of 10 mg/l during summer operations and 15 mg/l during winter periods, the equivalent nitrogenous BOD (should all the ammonia be converted to nitrates) is approximately 43 mg/l (summer) and 65.0 mg/l (winter). This is greater than the carbonaceous BOD of most secondary effluents.

Modified Iowa Model

The Modified Iowa model is a minor refinement of computer program historically used by the Department since 1976 to determine wasteload allocations. These refinements were recommended by the consulting firm, JRB Associates, McLean, Virginia, as part of their review of the Department's water quality models. The specific modifications are presented in a Users Manual and described in detail later in this section. The major changes include: replacement of the existing temperature adjustments for nitrification rates, equations to account for alage uptake of ammonia and a photosynthesis minus respiration (P-R) term for improvement of summer dissolved oxygen simulation. A copy of the complete users manual is available from the Department ("User's Manual for Modified Iowa DEQ Model", June, 1983).

1. Dissolved Oxygen Deficit Equation

   The Modified Iowa model uses a version of the Streeter-Phelps equation for DO deficit within the stream. This approach recognizes both carbonaceous and nitrogenous BOD, atmospheric reaeration initial DO deficit and photosynthesis. Effects of photosynthesis and benthal oxygen demands are not specifically considered. The modified Streeter-Phelps equation suggested for use by JRB Assiciates is as follows:

$$D(t) = \frac{K_1 L_0}{K_2 - K_1}\left(e^{-K_1 t} - e^{-K_2 t}\right) + \frac{K_n N_0}{K_2 - K_n}\left(e^{-K_n t} - e^{-K_2 t}\right) + D_0 e^{-K_2 t} + \frac{(R-P)}{K_2}\left(1 - e^{-K_2 t}\right)$$

   where:

   $D(t)$ = DO deficit at time t (mg/l)
   D_0 = Initial DO deficit (mg/l)
   L_0 = Initial ultimate carbonaceous BOD (mg/l)
   N_0 = Initial ultimate nitrogenous BOD (mg/l)
   K_1 = Carbonaceous deoxygenation rate constant, base e (day^{-1})
   K_n = Nitrogenous deoxygenation rate constant, base e (day^{-1})
   K_2 = Reaeration rate constant, base e (day^{-1})
   R = Algal respiration oxygen utilization (mg/l/day)

P = Photosynthetic oxygen production (mg/l/day)
T = Time of travel through reach (day)

In this equation, the rates of oxygen utilization due to carbonaceous and nitrogenous BOD and algal activity are expressed as first order reaction rates. This is an accepted procedure for the carbonaceous demand, but represents a simplification for the nitrogenous demand. The "P-R" term represents the modification to the traditional Streeter-Phelps equations to account for algal influences to the available dissolved oxygen in the stream. The other traditional Streeter-Phelps components (Streeter, 1925) remain unchanged. The "P-R" term was obtained from the MS-ECOL fresh water model (Shindala _et._ _al_., 1981).

Ultimate carbonaceous and nitrogenous BOD concentrations as a function of time (t) are calculated as follows:

$$L(t) = L_o e^{-K_1 t}$$

$$N(t) = N_o e^{-K_n t}$$

where:

L(t) = Ultimate carbonaceous BOD at time (t) (mg/l)
N(t) = Ultimate nitrogenous BOD at time (t) (mg/l)

Since nitrification is a two-step process, many researchers have proposed that it is a second order reaction. However, most water quality models assume that it is a first order reaction for ease of programming and usage.

Nitrifying bacteria are generally present in relatively small numbers in untreated wastewaters. The growth rate at 20°C is such that the organisms do not exert an appreciable oxygen demand until about eight to ten days have elapsed in laboratory situations. This lag period, however, may be reduced or eliminated in a stream due to a number of reasons including the following: (1) discharge of large amounts of secondary effluent containing seed organisms, (2) nitrifier population buildup on the stream's wetted perimeter. In biological treatment systems, substantial nitrification can take place with a resultant build-up of nitrifying organisms. These nitrifying bacteria can immediately begin to oxidize the ammonia present and exert a significant oxygen demand in a stream below the outfall.

It is known that the biological nitrification process is generally more sensitive to environmental conditions than carbonaceous decomposition. The optimal temperature range for growth and reproduction of nitrifying bacteria is 26° to 30°C. It is generally concluded that the nitrogenous BOD will assume greatest importance in small streams which receive relatively large volumes of secondary wastewater effluents during the low flow, warm weather periods of the year (August and September). These conditions were used for the low flow determination of allowable effluent characteristics during summer periods. During winter low flow periods (January and February), nitrification will probably have limited influence upon the oxygen demand due to the intolerance of nitrifying bacteria to low temperatures. During analysis of winter low flow conditions, limited nitrification was observed to be occurring.

2. Respiration and Photosynthesis Equation

The equations used to calculate P, the photosynethic oxygen production, and R, the algal respiration oxygen utilization, are:

$$P = \frac{(OP)(GP - DP)(CHLA)}{AP}$$

where:

OP = mg oxygen produced by algae/mg algae
AP = ug chlorophyll-a/mg algae
GP = algal growth rate (day^{-1})
DP = algal death rate (day^{-1})
$CHLA$ = chlorophyll-a concentration (ug/l)

and

$$R = 0.025\ CHLA$$

The values of OP, AP and DP are selected from literature values by the modeler. Current literature values are presented in Table IV-1 (Page 19). It is essential that chlorophyll-a measurements be available from the stream sampling data. If not, chlorophyll-a values must be estimated by general field observation or conditions on similar stream and calibration, which detracts from the credibility of the calibration. Since nitrate and inorganic phosphorus are not included in the model, the growth rate (GP) must be calculated outside the model using the equation:

$$GP = \bar{u}\left(\frac{N}{N + K_{MN}}\right)\left(\frac{P}{P + K_{MP}}\right)\left(\frac{LI}{LI + K_{LI}}\right)$$

where:

GP = local algal growth rate at 20°C (day^{-1})

$\bar{u}$ maximum specific algal growth rate at 20°C (day^{-1})
N = sum of observed instream concentrations of NH_3-N and NO_3-N (mg/l)
K_{MN} = Michaelis-Menton half-saturation constant for total inorganic N (mg/l)
P = observed instream concentration of inorganic phosphorus (mg/l)
K_{MP} = Michaelis-Menton half-saturation constant for inorganic P (mg/l)
LI = average incident light intensity (kcal/m^2-sec)
K_{LI} = Michaelis-Menton half-saturation constant for light (kcal/m^2-sec)

Literature values for $\bar{u}$, K_{MN}, K_{MP}, LI, and K_{LI} are found in Table IV-1.

The values of OP and AP are input as constants for the entire stream, while GP, DP and CHLA are specified for each reach. The Michaelis-Menton constants are used to adjust the maximum potential algal growth rate by the amounts of light, nitrogen, and phosphorus that can limit algal growth. Each constant is the concentration at which that particular constituent limits algal growth to half the maximal or "saturated" value.

3. Algal Uptake of Ammonia Equation

Another new feature in the Modified Iowa model is the simulation of algal uptake of NH_3-N. The instream concentrations of inorganic nutrients are reduced by phytoplankton consumption. Phytoplankton requirements for inorganic N may involve both ammonia nitrogen (NH_3-N) and nitrate nitrogen (NO_3-N). The fraction of consumed nitrogen which is NH_3-N must be known if instream concentrations of NH_3-N are to be properly simulated. This fraction is the preferential NH_3 uptake factor.

The amount of NH_3-N removed by algae in a reach is calculated by the following equation taken from the MS-ECOL model (Shindala et. al., 1981):

$$UP = \frac{(GP)(ANP)(NF)(CHLA)(e^{(GP-DP)(t)} - e^{-(K_N)(t)})}{(GP - DP + K_N)}$$

where:

UP = amount of NH_3-N removed in a reach (mg/l)
ANP = mg N / ug chlorophyll-a
NF = fraction of NH_3 preferred for algal uptake (0 - .9)
t = time of travel through reach (day)

The model calculates t internally. The values for ANP and NF are obtained by calibration or from literature values. Ranges of literature values are found in Table IV-1. The model assumes that algal uptake of ammonia occurs until the instream concentration of NH_3-N is equal to the inorganic N half-saturation constant K_{MN}. If the instream concentration of NH_3 is below the half-saturation constant, the technical literature indicates that algae will switch to NO_3 as the sole source of nitrogen.

4. Rate Constant Determination

a. Deoxygenation Rate Constants

The carbonaceous deoxygenation rate constant (K_1) for most streams will vary from 0.1 to 0.5 per day (base e, 20°C). Early work by Streeter and Phelps (Streeter, 1925) determined an average value for the Ohio River of 0.23/day at 20°C (0.1/day, base 10). This value has been accepted and commonly used for years with reasonable results.

Specific deoxygenation rates for selected Iowa stream segments have been determined from stream surveys performed since 1977. These specific rates showed wide variations within each stream segment and between various streams. Thus, the carbonaceous deoxygenation rate of 0.2/day at 20°C is still used as an initial starting point in calibration/verification efforts. Future stream studies will be used to verify the specific rates applicable for Iowa streams.

Information on nitrogenous deoxygenation rates is extremely limited; however, available information indicates that nitrification rates (when active nitrification does occur) are somewhat greater than carbonaceous oxidation rates. Therefore, a nitrogenous deoxygenation rate (K_N) (of 0.3/day at 20°C was selected) as input data unless calibration/verification efforts provide a more reliable value. Again, future field measurements of typical nitrogenous deoxygenation rates in Iowa streams would greatly enhance the accuracy of the modeling effort.

The modified model alters the value of K_N within each reach as a function of the stream DO concentration. Because nitrifying bacteria are very sensitive to DO levels, K_N is reduced when low DO conditions exist. The following equation, which accounts for the effect of DO concentrations on nitrification rates, is taken from the Wisconsin QUAL III Model (WDNR, 1979):

$$PN = 1-e^{-(.52)(DO)}$$

where:

PN = nitrification reduction factor
DO = dissolved oxygen concentration (mg/l)

The K_N value input to the model is multiplied by the reduction factor PN. The product is the value of K_N which is used in the dissolved oxygen deficit and nitrogenous BOD equations.

b. Reaeration Rate Constant

The particular formulation used on Iowa streams incorporates the recently developed relationship of Tsivoglou and Wallace (Tsivoglou, 1972) adopted for determination of the reaeration rate constant. This formulation is based on the premise that the reaeration capacity of nontidal fresh water streams is directly related to the energy expended by the flowing water, which in turn is directly related to the change in water surface elevation.

The change in water surface elevation divided by the time of flow is the average rate of energy expenditure. The original Tsivoglou and Wallace formulation has been modified to account for the percentage of ice cover. This relationship is expressed by:

$$K_2 = \frac{c\Delta h\ (ICE)\ (at\ 20°C)}{t}$$

where:

K_2 = Reaeration rate constant (1/day), base e
c = Gas escape coefficient (1/ft)
Δh = Change in water surface elevation (ft)
ICE = Factor reflecting effect of ice cover on reaeration rate (unitless) (ICE = 1-% ice cover)
t = Time of travel (days)

Tsivoglou's equation was derived from actual measurement of stream reaeration rates by a new field tracer procedure in which a radioactive form of the noble gas krypton serves as a tracer for oxygen.

The calibration results for sampled Iowa streams have indicated that the following guidelines are appropriate with respect to the gas escape coefficient incorporated in the Tsivoglou expression:

$$c = 0.054\ (@20°C)\ \text{for}\ 15 \leq Q \leq 3000\ \text{cfs}$$

$$c = 0.115\ (@20°C)\ \text{for}\ 0 \leq Q \leq 15\ \text{cfs}$$

Other calibrated/verified values may be used on streams with sufficient water quality data.

In development of Tsivoglou's procedure, other reaeration rate predictive formulas were compared with results obtained from the field tracer technique, but none appeared to predict stream reaeration rates as accurately as the Tsivoglou model.

The ICE factor ranges from 0.05 for complete ice cover to 1.0 for zero cover. The selected input value is based on available field data or estimated by the modeler.

5. Temperature Corrections

Temperature corrections for the carbonaceous and nitrogenous deoxygenation rate constants and also the reaeration rate constants are performed within the computer model. The following equations define the specific temperature corrections used in the program:

$$K_{1(T)} = K_1(20) \times 1.047^{T-20}$$

$$K_{2(T)} = K_2(20) \times 1.0159^{T-20}$$

$$K_{n}(T) = K_n(20) \times 1.080^{T-20}$$

$$GP_{(T)} = GP_{(20)} \times 1.047^{T-20}$$

where:

T = Water Temperature, °C

This temperature correction for K_1 represents the state-of-the-art, and is a widely accepted formulation. The K_2 and K_N equations represent the more accepted functions used in the Vermont QUAL-II model (Meta Systems, 1979). The growth rate temperature correction is taken from the MS-ECOL model (Shindala et. al., 1981).

The principal factor affecting the solubility of oxygen is the water temperature. Dissolved oxygen saturation values at various temperatures are calculated as follows:

$$C_s = 24.89 - 0.426T + 0.00373T^2 - 0.0000133T^3$$

where:

T = Water temperature, °F
C_s = Saturation value for oxygen at temperature, t (°F), at standard pressure.

6. Stream Velocity Calculations

Stream velocities are important in determining reaeration rates and the downstream dispersion of pollutants. The computer model used calculates velocity based on either a variation of the Manning Formula for open channel flow and the Leopold-Maddock predictive equation.

a. Manning Formula

The Manning Formula for open channel flow is:

$$v = \frac{1.49 R^{2/3} S^{1/2}}{n}$$

where:

v = Velocity (fps)
R = Hydraulic radius (ft)
S = Channel Slope (ft/ft)
n = Roughness coefficient

For a river or stream with a width much greater than its depth, the value of R is approximately equal to the mean depth. If both sides of the equation are multiplied by the cross-sectional area (width x mean depth), the following equation results:

$$Q = \frac{1.49}{n} \; wd^{5/3} S^{1/2}$$

where:

d = Mean river depth (ft)
Q = Discharge (cfs)
w = Water surface width (ft)
S = Slope (ft/ft)
n = Roughness coefficient

All values except d are input values. Internally, the program solves the above equation for d, then calculates the velocity v by:

$$v = Q/A = Q/wd$$

River slopes were obtained from existing stream profiles when available, but usually were taken from USGS topographic maps. Slopes obtained from USGS maps are rather generalized, and more accurate river profiles would greatly improve the accuracy of velocity determinations.

River widths were estimated from information obtained from field observations and flow and cross-sectional data at each USGS gauging station.

Roughness coefficients are estimated from charts and techniques presented in Chow (Chow, 1965). The value of 0.035 is being used on Iowa streams unless the physical characteristics of the stream are more accurately reproduced by another value.

In developing the particular model run for a stream segment, depth and velocity data from stream gauging stations or from field surveys is used to extrapolate depth and velocity at other points along the segment. The extrapolation is a rough approximation; however, it is reasonably close over the average length of a stream. When available, the use of field investigations to determine actual stream velocities and depths at many selected stream sites in the modeled segment have improved the accuracy of the model.

The Manning equation is used where little historical flow and velocity information exists in the stream segment. If flows and velocities are measured during a calibration sampling event, the roughness coefficient n can be calibrated. However, in most instances, a more reliable flow, velocity relationships can be modeled by using the Leopold-Maddock equation.

b. Leopold-Maddock Equation

The Leopold Maddock (Leopold, 1953) equation predicts stream velocity as a function of discharge according to:

$$V = aQ^b$$

where:

V = Stream velocity (ft/sec)
Q = Discharge (cfs)
a, b = Empirical constants

It is significant to point out that the empirical constants, a and b, apply to a specific stream cross section. The value of b represents the slope of a logarithmic plot of velocity versus discharge and a represents the velocity at a discharge of unit (i.e., the y-axis intercept).

The Leopold-Maddock equation has been used in many studies and has been found to produce reliable results when the empirical constants are properly evaluated. Its use is limited, however, to streams for which considerable historical data are available for determining representative values for the empirical constants. A regression analysis is performed on several sets of velocity-discharge data to determine the empirical constants. The data selected for use in the analysis corresponds to low flow conditions since the use of high flow data may bias the results.

Since stream systems are rarely characterized by reaches of uniform cross section, slope, and roughness parameters, the empirical constants are determined for several representative cross sections of each stream system to be modeled. The same values of the empirical constants usually do not apply to all reaches along a stream segment unless field measured data indicates such is the case. JRB Associates staff indicated the a value for "b" of .25 is commonly used for smaller streams and rivers such as found in Iowa. Thus, where limited field information exists, "a" can be determined if "b" is assumed to equal 0.25 by solving the above equation. The use of this assumption will occur only if insufficient flow or stream cross sectional data exist from various available sources. Data sources for velocity and discharge values are the USGS gauging station data forms 9-207 or from stream surveys obtaining current meter and cross section measurements.

7. Computer Input and Output Data

In order to calculate water quality at various points in the river, the river length to be modeled was divided into reaches. River characteristics such as mean widths, depths, velocities, deoxygenation and reaeration rate constants, and water temperatures were considered for each small reach. The overall stream length modeled was kept to less than 20 miles to insure steady state conditions. The location of the reaches was set by one or more of the following:

a. A tributary.
b. A wastewater discharge.
c. A change in river characteristics, such as river width or slope.
d. A dam.

In order to calculate water quality characteristics at various points within each reach, the reaches were divided into segments called sections.

Actual data input into the computer program are as follows:

1. Initial river conditions such as flow and concentrations of ultimate carbonaceous BOD, ammonia nitrogen, DO.

2. Uniform background flow contributions for each reach and concentrations of ultimate carbonaceous BOD, ammonia nitrogen, and DO in the ground water.

3. The number of reaches.

4. For each reach the following:

   a. Length
   b. Number of sections
   c. Water temperature
   d. Channel Slope
   e. River width
   f. Roughness coefficient

   (c–f) used in Tsivoglou & Manning equations

   g. Deoxygenation rate constants
   h. Empirical constants - Leopold-Maddock equation
   i. Ice Cover

5. Wastewater or tributary inflows consisting of inflow rates, ultimate carbonaceous BOD ammonia nitrogen, and DO concentrations.

The computer printout of the model run includes a reformat of all input data and key calculated data for each stream reach and segment.

This calculated data includes:

1. Stream Velocity
2. Rate Constants
3. Saturated Dissolved Oxygen Concentration
4. Travel Time
5. BOD_u, NH_3-N and Dissolved oxygen instream concentrations

An example of the output is found in the User's Manual.

TABLE IV-1
TYPICAL VALUES OF INPUT VARIABLES
FOR MODIFIED IOWA MODEL

VARIABLE	DESCRIPTION	RANGES OF VALUES	RECOMMENDED WLA VALUE
NF	Preferential NH_3 Uptake Factor	0 - 0.9	Calibrate
ANP	mg Nitrogen/ug Chlorophyll-a	.0007 - .009	Calibrate
K_{MN}	Michaelis-Menton Half-saturation Constant for Nitrogen (mg/l)	.01 - .20	Calibrate
K_{MP}	Michaelis-Menton Half-saturation Constant for Phosphorus (mg/l)	.01 - .05	Calibrate
K_{LI}	Michaelis-Menton Half-saturation Constant for Light (mg/l)	-----	.0035
AP	ug Chlorophyll-a/mg Algae	10 - 100	Calibrate
OP	mg Oxygen Produced by Algae/mg Algae	1.4 - 1.8	1.63
K_1	Carbonaceous Deoxygenation Rate Constant (day^{-1})	.02 - 3.4	Calibrate
K_N	Nitrogenous Deoxygenation Rate Constant (day^{-1})	.3 - 3.0	Calibrate
C	Tsivoglou Escape Coefficient (ft^{-1})	-----	.054, $15 \leq Q \leq 3000$ cfs .110, $1 \leq Q \leq 15$ cfs
$\overline{u}$	Maximum Algal Growth Rate (day^{-1})	1 - 3	2
DP	Local Algal Death Rate (day^{-1})	.024, .24	Use higher value if nutrients are scarce or chlorophyll-a concentration exceeds 50 ug/l; otherwise use lower value
ICE	Factor Relating Ice Cover to Reduced Reaeration Capacity	.05 - 1.0	Field observation

Vermont QUAL-II Model

The Vermont QUAL-II water quality model can simulate conservative and nonconservative constituents in branching stream and river systems. The constituents which can be modeled by the revised version of QUAL-II are:

° Dissolved Oxygen (DO)

° Biochemical Oxygen Demand (BOD)

° Temperature

° Algae

° Organic Nitrogen

° Ammonia (NH_3-N)

° Nitrite (NO_2-N)

° Nitrate (NO_3-N)

° Dissolved Phosphorus

° Organic Phosphorus

° Coliform

° Conservative Substances

The model was adapted for Iowa conditions and needs by JRB Associates. A copy of the detailed User's Manual can be obtained from the Department ("User's Manual for Vermont QUAL-II Model", June, 1983). The User's Manual will provide documentation of the theoretical aspects of the model, as well as a description of the model input and data requirements. The following discussion is, in part, key items from the User's Manual. The size and complexity of the document prohibits its reproduction in this chapter of the "Basin Plan Support Document".

1. Background

The QUAL-II model is an extension of the stream model, QUAL-I, developed by F. D. Masch and Associates, and the Texas Water Development Board in 1971. QUAL-I was originally designed to simulate the dynamic behavior of conservative materials, temperature, BOD and DO in streams.

Water Resources Engineers, Inc. (WRE) revised the QUAL-I model to include the steady state simulation of NH_3, NO_2, NO_3, dissolved phosphorus, algae and coliforms as well as DO and BOD. This WRE QUAL-II model has since undergone numerous revisions to incorporate additional parameters and changes in constituent interactions. The version of QUAL-II which is used by the Department is the Vermont version of QUAL-II.

The Vermont QUAL-II is basically a version developed by Meta Systems, Inc. (1979), with later modifications by Walker (1980, 1981) and the Vermont Department of Water Resources and Environmental Engineering (1981). The changes Meta Systems introduced in 1979 to U.S. EPA's version of QUAL-II include the following:

- Incorporation of the simulation of organic nitrogen.
- Provision for algal uptake of ammonia as a nitrogen source.
- Steady state calculation of diurnal oxygen variations due to algal photosynthesis and respiration based on diel curve analysis.
- Changes in the model to delete the dynamic simulation of DO, thus allowing dynamic simulation of temperature only.
- Inclusion of dam reaeration.

° Changes in the methods used to calculate the reaeration coefficient, K_2.

° Deletion of the radionuclide simulation.

To this Meta Systems version of QUAL-II, Vermont has added the simulation of organic phosphorus and has modified the expressions for algal kinetics.

The majority of the information in the User's Manual came from the following four sources:

a. Roesner, L. A., Giguere, P. R. and Evenson, D. E. Feb. 1981. Computer Program Documentation for Stream Quality Modeling (QUAL-II). U.S. EPA Center for Water Quality Modeling, Environmental Research Laboratory, Athens, GA. EPA-600/9-81-014.

b. Roesner, L. A., et al. Feb. 1981. User's Manual for Stream Quality Model (QUAL-II). EPA-600/9-81-015.

c. Meta Systems, Inc. July 1979. Documentation for the Meta Systems Version of the QUAL-II Water Quality Simulation Model.

d. State of Vermont, Agency of Environmental Conservation, Department of Water Resources and Environmental Engineering. Jan. 1982. Lower Winooski River Wasteload Allocation Study, Part B: Mathematical Modeling Report.

2. Stream System Representation

QUAL-II permits any branching, well-mixed stream system to be modeled. It assumes that the major transport mechanisms, advection and dispersion, are significant only along the longitudinal axis of the stream. It can handle multiple waste discharges, withdrawals, tributary flows, incremental inflow, flow augmentation, and dam reaeration. Hydraulically, QUAL-II is limited to the simulation of time periods during which the steam flows in the river basin are essentially constant (Roesner, et al., 1981). Thus, the length of river or stream to be modeled is relatively short, less than 20 miles. The length should be long enough to account for the decay of organic pollutants and the recovery to near background conditions. The use of this model is not suitable for one run over the entire stream or river length.

Streams to be simulated by QUAL-II are divided into reaches, and further subdivided into computational elements. River reaches are the basis of most data input. Hydraulic data, reaction rate coefficients, initial conditions, and incremental inflow data are constant for all computational elements within a reach. For the purposes of QUAL-II, the stream is conceptualized as a network of completely mixed reactors -- computational elements -- which are linked sequentially to each other via the mechanisms of transport and dispersion (Roesner, et al., 1981).

Although QUAL-II has been developed as a relatively general program, Roesner, et al. (1981) cite certain dimensional limitations which have been imposed upon it during program development. These limitations are as follows:

Reaches:	a maximum of 75
Computational elements:	no more than 20 per reach nor 500 in total
Headwater elements:	a maximum of 15
Junction elements:	a maximum of 15

Input and withdrawal elements: a maximum of 90 in total

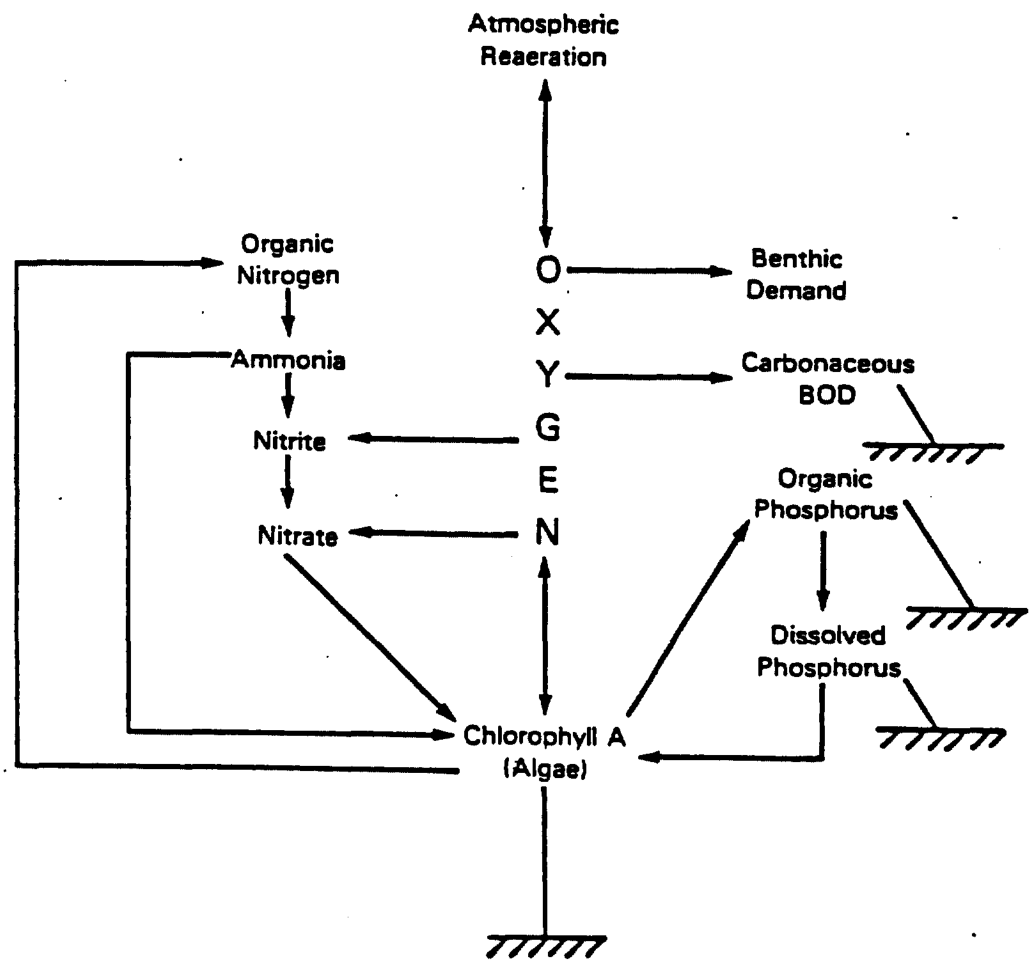
QUAL-II makes certain assumptions about the stream system being simulated, including the following:

- QUAL-II assumes first order kinetics.
- The model utilizes a simplified nutrient-algal cycle with Michaelis-Menton kinetics.
- Only constant inflows and point source discharges are considered in the model.
- Each computational element is assumed to be completely mixed.
- The model does not take into account variations in depth or within stream cross section in each.

3. General Model Relationships

QUAL-II utilizes a mass balance differential equation which describes the behavior of a water quality constituent in one dimension. The model is structured to simulate the major interactions of the nutrient cycles, algal production, benthic oxygen demand, carbonaceous oxygen uptake, atmospheric reaeration, and the effect these processes have on receiving water concentrations of dissolved oxygen. The interactions of all these constituents are illustrated in Figure IV-1. Arrows on Figure IV-1 indicate the direction of normal system progression in a moderately polluted environment; the directions may be reversed in some circumstances for some constituents. Roesner, et al. (1981) point out an example of process reversal: under normal conditions, oxygen will be transferred from the atmosphere into the water. Under conditions of oxygen supersaturation, which can occur as a

Figure IV-1
General Model Structure for QUAL-II



Source: Vermont, 1982

result of algal photosynthesis, oxygen might actually be driven from solution, causing the direction of flow to reverse.

Coliforms are modeled as nonconservative decaying constituents, and do not interact with other constituents. The conservative constituents, of course, neither decay nor interact in any way with other constituents.

The detailed mathematical relationships that describe the individual reactions and interactions are presented in the User's Manual. Their inclusion would make this document very lengthy and cumbersome. A brief discussion on the mathematical relationships for phytoplanktonic algae are included as this is one of the significant improvements over the past available model.

The chlorophyll-a concentration in a stream system is assumed to be directly proportional to the concentration of phytoplanktonic algal biomass. In QUAL-II, algal biomass is converted to chlorophyll a by the simple relationship:

$$\mathrm{Chl}\text{-}\underline{a} = a_0 A$$

where:

$\mathrm{Chl}\text{-}\underline{a}$ = chlorophyll-a concentration (ug/liter)
$\bar{A}$ = algal biomass concentration (mg/l)
a_0 = a conversion factor - chlorophyll a to algae ratio

The growth of algae (chlorophyll-a) is calculated according to the following differential equation:

$$\frac{dA}{dt} = uA - p_0 A - \frac{s}{d} A$$

where:

A = algal biomass concentration (mg/l)
t = time
u = the local specific growth rate of algae which is temperature dependent (1/day)

p_0 = algal death rate (1/day)
s = the local settling rate for algae (ft/day)
d = average depth (ft)

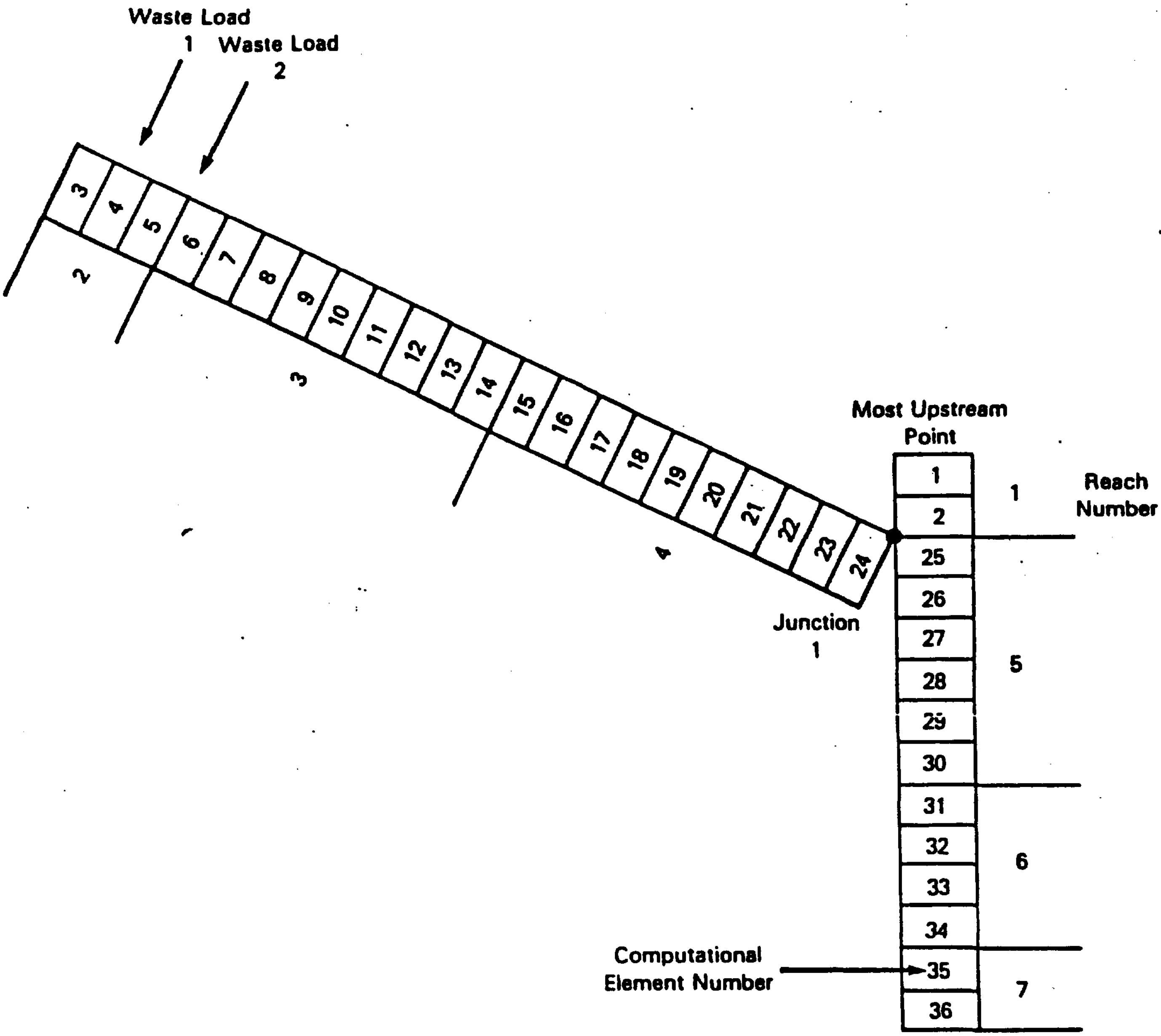
It should be noted that the local algal growth rate is limited by light and either nitrogen or phosphorus, but not both. Thus, nutrient/light effects are multiplicative but nutrient/nutrient effects are alternate (Walker, 1981). The specific expression used to calculate local algal growth rates are listed in the User's Manual. In the QUAL-II model, the "algal respiration rate" controls only the uptake of oxygen by algae, while the "algal death rate" governs both the change in algal biomass due to endogenous respiration and the conversion of algal P to organic P. The "algal N to organic N" term represents the conversion of algal N to organic N. Algae are assumed to use ammonia and/or nitrate as a source of nitrogen. The effective concentration of available nitrogen is the sum of both concentrations. The algal growth rate and death rates are temperature dependent. They are corrected within the model, as are all other temperature dependent system variables, according to the procedure explained in the User's Manual.

4. Input Data

The first step in setting up the input data for QUAL-II is to prepare a graphic representation of the stream system, similar to that shown in Figure IV-2. The best way to begin this is to locate the sampling stations, point source discharges, and stream junctions on USGS topographic maps. Stream miles can then be computed using a map wheel or other measuring device.

As shown in Figure IV-2, the stream must be divided into reaches. Reaches are stretches of stream that exhibit uniform hydraulic characteristics.

Figure IV-2
Sample Reach Network



The reaches are themselves divided into computational elements, which must be the same length throughout the stream system. The length chosen for the computational elements is determined by the degree of resolution needed to approximate the processes taking place in the stream. For example, if the observed dissolved oxygen concentration goes from saturated concentration to critical concentration and back to saturated concentration over an interval of about five river miles, a degree of resolution of less than one mile is appropriate (Roesner, et al., 1981).

A sketch should be made of the stream reach configuration and the elements numbered. Each computational element is numbered sequentially, beginning with the uppermost point of the stream and proceeding downstream. When a junction is reached, the numbering scheme proceeds from the main stream element immediately upstream of the junction, to the uppermost point of the tributary, and continues downstream. Figure IV-2 illustrates this numbering sequence.

Each computational element in the stream reach network is classified into element types. These element types provide the location of discharges, withdrawals, tributaries, etc. The seven element types used in QUAL-II are:

Number	Type
1	Headwater source element
2	Standard element, incremental inflow only
3	Element on main stream immediately upstream of a junction
4	Junction element
5	Most downstream element
6	Input element
7	Withdrawal element

Special attention should be paid to the numbering of elements, particularly at the junctions. The point source loads are numbered downstream in the order of the elements. Any withdrawals are counted as a point source load in the numbering scheme. It is important that this be done correctly, since QUAL-II associates the first wasteload card with the first type 6 or 7 element in the stream configuration. The same is true of the order of the headwaters.

For informational purposes, the following types of input data groups show the complexity and flexibility of the QUAL-II program. These 12 groups each contain different categories of information which the user must supply to the program.

Card Type 0	Titles
Card Type 1	Control Data
Card Type 1A	Model Parameters
Card Type 2	Reach Identification
Card Type 3	Flow Augmentation Data
Card Type 4	Computational Element Flag Fields
Card Type 5	Hydraulic Data
Card Type 6	BOD and DO Reaction Rates
Card Type 6A	Algae, N and P Constants
Card Type 6B	Other Coefficients
Card Type 7	Initial Conditions
Card Type 7A	Initial Conditions (continued)
Card Type 8	Incremental Runoff Conditions
Card Type 8A	Incremental Runoff Conditions (continued)
Card Type 9	Stream Junction Data
Card Type 10	Headwater Sources
Card Type 10A	Headwater Sources (continued)
Card Type 11	Point Source Inputs and Withdrawals
Card Type 11A	Point Source Inputs and Withdrawals (continued)
Card Type 12	Dam Reaeration Data

Specific input sequences and formats are presented in the User's Manual. Detailed procedures for calibrating the rate constants to specific stream conditions are also presented in the User's Manual. While running the program for a specific stream or for calibrating a segment, the suggested ranges for reaction coefficients are presented in Table IV-4. These values serve as a guide for a run of the QUAL-II program.

TABLE IV-4
RECOMMENDED RANGES FOR REACTION COEFFICIENTS
FOR QUAL-II

DESCRIPTION	UNITS	RANGE OF VALUES
Ratio of chlorophyll-a to algae biomass	$\frac{\text{ug Chl-a}}{\text{Mg A}}$	10-100
Fraction of algae biomass that is Nitrogen	$\frac{\text{Mg N}}{\text{Mg A}}$	0.07-0.09
Fraction of algae biomass that is Phosphorus	$\frac{\text{Mg P}}{\text{Mg A}}$	0.01-0.02
O_2 Production per unit of algal growth	$\frac{\text{Mg O}}{\text{Mg A}}$	1.4-1.8
O_2 Uptake per unit of algae respired	$\frac{\text{Mg O}}{\text{Mg A}}$	1.6-2.3
O_2 Uptake per unit of NH_3 oxidation	$\frac{\text{Mg O}}{\text{Mg N}}$	3.0-4.0
O_2 Uptake per unit of NO_2 oxidation	$\frac{\text{Mg O}}{\text{Mg N}}$	1.0-1.14
Rate constant for the biological oxidation of NO_2 to NO_3	1/Day	0.10-1.00
Rate constant for the biological oxidation of NO_2 to NO_3	1/Day	0.20-2.0
Rate constant for the hydrolysis of organic-N to ammonia	1/Day	0.02-0.4
Dissolved phosphorus removal rate	1/Day	0.01-0.10
Organic phosphorus settling rate	1/Day	0.001-0.10
Algal settling rate	ft/Day	0.5-6.0
Benthos source rate for phosphorus	$\frac{\text{Mg P}}{\text{day-ft}}$	Highly Variable
Benthos source rate for NH_3	$\frac{\text{Mg N}}{\text{day-ft}}$	Highly Variable
Organic P decay rate	1/Day	0.1-0.7
Carbonaceous deoxygeneration rate constant	1/Day	0.02-3.4

TABLE IV-4
RECOMMENDED RANGES FOR REACTION COEFFICIENTS
- Continued -

DESCRIPTION	UNITS	RANGE OF VALUES
Reaeration rate constant	1/Day	0.0-100
Rate of loss of CBOD due to settling	1/Day	-0.36 to 0.36
Benthic oxygen uptake	$\frac{\text{Mg O}}{\text{day-ft}}$	Highly Variable
Coliform die-off rate	1/Day	0.5-4.0
Maximum algal growth rate	1/Day	1.0-3.0
Algal death rate	1/Day	.024-.24
Preferential NH_3 uptake factor	--	0.0-0.9
Algal N to organic N decay rate	1/Day min	.11
Algal respiration rate	1/Day	0.05-0.5
Michaelis-Menton half-saturation constant for light	Langleys	0.02-0.10
Michaelis-Menton half-saturation constant for nitrogen	Mg/l	0.01-0.20
Michaelis-Menton half-saturation constant for phosphorus	Mg/l	0.01-.05
Non-algal light extinction coefficient	1/ft	Variable
Algal light extinction coefficient	$\frac{\text{1/ft}}{\text{ug Chl-a/L}}$	.005-.02

Since the QUAL-II program is written in FORTRAN, it is essential that the input data be in the correct format for the program to run.

MODELING DATA SOURCES

The bulk of the work in stream water quality modeling is the collection and interpretation of all available data describing the stream system to be modeled. This section describes procedures and data sources that may be used in stream modeling for wasteload allocation work.

Wastewater Discharges - Required data for each discharger are effluent flow rates and effluent characteristics such as BOD, NH_3-N and DO concentrations and temperature. The specific location and characteristics of some smaller wastewater discharges are often unknown and are determined from field investigations or during special stream surveys. Most wastewater discharge information is available in Departmental files.

River Miles - The first step in modeling a river system is determining the locations of all tributaries, wastewater dischargers, dams and other critical points along the river. The total length of the main channel of the river to be modeled must be established and river miles need to be located such that the location of tributaries, etc., can be determined to the nearest one-tenth of a mile. Often the U.S.G.S. or Corps of Engineers have located river miles on larger streams, but in some instances these river miles are incorrect or do not correspond to the existing stream channel. Experience has shown that it is best to start from the beginning with the best available base map and establish river miles by use of appropriate measuring techniques. The best maps to start with are U.S.G.S. topographic maps. These consist of section maps (scale: 1:250,000) and quadrangle maps (scale: 1:24,000). Section maps are available for the state while quadrangle maps are not completed for some areas. Other maps such as state and county road maps can also be used to supplement the U.S.G.S. maps.

Field Reconnaissance - During special stream surveys the following data can be easily collected:

1. The precise location of wastewater discharges.
2. The location, condition, height and type of dams and the nature and approximate length of the pool created by the dam.
3. Approximate river widths at bridge crossings.
4. Approximate shape of channel cross sections.
5. Channel characteristics that will be an aid in determining channel roughness coefficients.

The special stream survey should be performed, if possible, during flow conditions that represent the flows used in the modeling effort. Stream discharge information during stream surveys may be verified from data obtained from the U.S.G.S. Discharges observed during stream surveys are almost greater than 7 day, 10 year low flows. Data such as river widths need to be extrapolated downward to represent 7 day, 10 year low flow conditions. Shapes of channel cross sections are an aid in this determination.

River Channel Slopes - After river miles and locations are established the next step is determination of river channel slopes. During low flow it can be assumed that river channel slopes are essentially the same as the slope of the water surface and channel profiles can be used as representative of water surface slopes. In some cases profiles of the river have already been determined.

This is usually done by the U.S. Army Corps of Engineers as part of work conducted prior to proposal or construction of flood control reservoirs. Without accurate profiles, river slopes can be determined from U.S.G.S contour maps by locating the points where contour lines cross the river. Stream slopes calculated from contour maps only represent an average value over the distance of the river between contour intervals. U.S.G.S. quadrangle maps (if available) are a more reliable source of slope data. Often, these are the only sources available and are the best method of slope determination without an extensive field survey.

River Widths and Roughness Coefficients - Estimation of river widths and roughness coefficients can occur in the field reconnaissance. Roughness coefficients can be estimated using charts and techniques in hydraulic texts and handbooks. One of the best references is Chow (Open-Channel Hydraulics, McGraw-Hill).

The variation of river widths with discharges can often be determined from data at U.S.G.S. gauging stations. The U.S.G.S periodically calibrates each gauge. The results from these calibrations are available on U.S.G.S form 9-207 and includes widths, cross-sectional area, mean velocities and discharges.

Reasonably accurate estimations of river widths at the desired discharge can usually be made with this gauging station information along with river widths measured during special stream surveys.

Stream Flow - In the determination of flow conditions throughout the river system to be modeled, all available data from U.S.G.S. flow measuring stations as well as flow rates of all wastewater discharges must be obtained. River flows need to be allocated among tributary, groundwater and wastewater inflow sources. The 7 day, 10 year low flows are used as the modeling basis, and are determined from a statistical analysis of the flow records at each of the gauging stations in the river system. Low flows have already been determined for partial and continuous gauging stations (e.g. Iowa Natural Resources Council, Annual and Seasonal Low-Flow Characteristics of Iowa Streams, Bulletin No. 13, 1979). The low flows at gauging stations must then be allocated to tributaries based on drainage areas. Tributary drainage areas may be available from existing publications e.g., Larimer, O.J., "Drainage Areas of Iowa Streams", Iowa Highway Research Bulletin No. 7, 1957) or they can be determined from U.S.G.S. contour maps.

A summation of tributary inflows and wastewater discharges often is less than the gauged flow. The difference is usually distributed along the main channel of the river as a uniform inflow in terms of cfs per mile of river reach length. If the gauged flow is less than the summation of tributary and wastewater inflows then it is possible to allot a uniform outflow from the main river channel.

Tributary and Groundwater Quality - Values for BOD, NH_3-N and DO of tributary and groundwater inflow are required for stream modeling. Often a main tributary to the stream being modeled has also been modeled. In this case the water quality of the tributary just before discharge into the main stream (as determined by the model) is used. If the tributary is small and has several wastewater discharges, hand calculations can be done to determine its water quality just before entering the main stream.

If the tributary is free of continuous discharging wastewater facilities, water quality has been assumed to be good. The tributary water quality input values are: ultimate BOD - 6 mg/l; NH_3-N concentrations - 0.0 mg/l (summer), 0.5 mg/l (winter); and DO at saturation.

Groundwater is also noted to be of high quality. The model input values for groundwater are ultimate BOD of 6 mg/l and NH_3-N at 0 mg/l. Groundwater DO's may be quite low depending on how it enters the stream. If it is subsurface flow, DO may be close to zero. Groundwater DO of 2 mg/l is used in wasteload allocation work in Iowa.

Rate Constants - The reaeration rate constant (K_2) is usually determined from one of many available predictive formulas. The one primarily used in the computer programs is based Tsivoglou formula.

Carbonaceous and nitrogenous deoxygenation rate constants are best determined experimentally for a specific wastewater effluent and/or calibrated for a specific stream. However, when specific values are not available "typical" values from similar streams may be used. In most cases the carbonaceous deoxygenation rate constant, K_1 will not be less than 0.2 per day (20°C). Values as high as 3.4 per day (20°C) have been reported in the literature.

Less information is available on the nitrogenous deoxygenation rate constants or nitrification rate in streams. Experimental work in Illinois (State of Illinois, Environmental Protection Agency, Guidelines for Granting of Exemptions from Rule 404(C) and 404(F) Effluent Standards, Oct., 1974) determined that the nitrogenous deoxygenation rate constant, K_n, ranged from 0.25 to 0.37 per day with an average value of 0.29 per day at 20°C. The current model uses a K_n value based on stream calibration from the modeled stream or similar streams. Other rate constants for benthic and algal kentics are based on calibration data or literature values. Specific explanation of these rate constants are in the user manuals for the modified Iowa and QUAL-II programs.

Dams and Impoundments - The damming of a stream creates special conditions for water quality modeling. For modeling purposes, dams and the resulting impoundments can be put into one of two classifications.

1. Large dams that back up rather extensive impoundments. Flow through the impoundment is not "plug flow" and inflow may be dispersed in a variety of vertical and horizontal directions.

2. Low-head dams which essentially make the river channel wider and deeper for a maximum distance of several miles. Flow through the impoundment is primarily "plug flow."

Class 1 dams and impoundments cannot easily be modeled to predict water quality. The modeling effort should be stopped at the beginning of the impoundment and started again below the dam. Water quality below the dam can be estimated from knowledge of the size of the impoundment, the method of water withdrawal and water quality data from stream surveys. Water taken from the lower levels of an impoundment during periods of summer stratification may be low in DO. If water flows over a spillway or an overflow weir it may be close to the DO saturation point. One can expect the BOD and NH_3-N concentrations in the discharge from large impoundments to be low unless the impoundment is highly eutrophic.

Class 2 dams and impoundments can be modeled by treating the impoundment as an enlarged or slower moving reach of the river. The length of the pool backed up by the dam may be divided into one or more reaches. Widths can be approximated from field observations. Slopes are taken as the water surface elevation and are quite small, generally elevation drops off no more than a foot over the length of the pool.

The dam may be treated as a reach 0.001 miles or 5.28 feet in length. The slope of this reach then becomes the dam height divided by 5.28 feet. The only water quality parameter that is significantly affected through the dam reach is the DO. Tsivoglou's reaeration rate constant prediction formula can be used to quite effectively predict reaeration over a dam. The equation for change in the DO deficit with time is:

$$D_t = D_0 e^{-K_2 t}$$

where:

D_t = DO deficit at time, t
D_0 = DO deficit at time zero
K_2 = Reaeration rate constant

Tsivolglou's reaeration rate constant predictive equation (neglecting ice conditions) is:

$$K_2 = \frac{c \Delta H}{t}$$

where:

c = escape coefficient
ΔH = change in elevation in time, t

Substituting into the DO deficit equation one obtains:

$$D_t = D_0 e^{-c \Delta H}$$

With a dam 10 feet high and c = 0.115/ft the ratio of D_t/D_0 is 0.32 or the deficit is 32 percent of the deficit at time zero. This is a DO deficit recovery of 68 percent.

Winter Conditions - Often the most critical period for maintaining water quality standards is winter low-flow periods instead of summer. Rates of deoxygenation are greatly reduced at the low temperatures, but ice cover also greatly reduces reaeration so that DO levels may be critical. Nitrification is significantly reduced at freezing temperatures. Consequently, ammonia concentrations may remain elevated over long stream reaches. Some loss of ammonia may occur in stream reaches due to algal uptake.

During winter periods reaeration rates may need to be reduced in proportion to the extent of ice cover. Even with 100 percent ice cover a small amount of reaeration undoubtedly takes place. In the waste load allocations reaeration rates were reduced in direct proportion to the estimated ice cover. The ice cover factor is assumed to vary in relationship to the amount of heated water in the discharge. The values range from 95% ice cover to 0% ice cover over the stream dams. Research and field investigations are needed on the effects of ice cover on stream reaeration rates and the extent of ice cover on specific stream reaches, in order to more precisely define the applicable reduction factor.

WASTELOAD ALLOCATIONS

Using the computer, wasteload allocations are determined for discharges in order to meet applicable State Water Quality Standards within the basin. Wasteload allocation analyses were performed for several seasonal conditions using projected year 2000 average dry weather wastewater discharge flows at the 7 day-1-in-10 year low stream ($7Q_{10}$) flow regime. Care must be taken in selecting the design discharge flow which would be expected during the $7Q_{10}$ stream flow or protected flow conditions. Some situations may warrant the use of average or wet weather design flows. Design flows will be obtained from facility plans, engineering reports or constructed permits.

Analysis is performed on stream designated either Class A, B or C with existing wastewater discharges and the tributaries classified for general uses only which receive wastewater discharge. This analysis is warranted to insure accurate consideration of field conditions for each type of stream. Some specific assumptions and considerations that are part of the analysis are discussed below.

Assumptions

In order to determine wasteload allocations for discharges within the state, specific assumptions are required. Identification of the major items required to evaluate and determine wasteload allocations are identified in the following list:

1. The major objective of the present hand calculations and the modeling activities is to assure that Iowa Water Quality Standards are met with the current and future effluent discharge flows. Modeling activities determine an allowable wasteload allocation by varying the allocation for point source discharges until the water quality model demonstrated that the oxygen concentrations would be maintained above 5.0 mg/l and ammonia nitrogen concentrations maintained below the water quality criteria levels in the designated stream segments at the 7 day, 1-in-10 year ($7Q_{10}$) or protected low flow. Hand calculations directly set the wasteload allocation through a dilutional relationship.

   One hundred percent of the low flow is used to assimilate the nonconservative pollutant (CBLD) in the wastewater discharge. The stream flow contained in the defined mixing zone is used to assimilate the conservative and toxic pollutants, such as ammonia nitrogen, TRC, metals, cyanide and toxics.

   The resulting wasteload allocation to meet stream standards will be the basis for establishing both maximum and average loading which the facility could discharge.

Specific $CBOD_5$ and NH_3-N will be noted as long as the values are less than those assumed for standard secondary (paragraph 7 below). If the average daily load exceeds the standard secondary level than the wasteload allocation would be set at standard secondary with no ammonia limitations. Only continuously discharging sources of wastewater are included in the modeling procedure. Waste stabilization ponds having controlled discharge capabilities were assumed not be discharging at low flow conditions.

2. Determination of 7 day, 1-in-10 year flow is required for each stream segment modeled. This low flow is tabulated in the USGS publication, "Annual and Seasonal Low Flow Characteristics of Iowa Streams," March 1979. On some very low flow stream segments which are predominantly wastewater, it may be important to determine the natural stream flow, not including Wastewater flow. The difference between the $7Q_{10}$ low flow and the wastewater discharge is assumed to be the result of groundwater inflow (or outflow) to the stream. This amount of groundwater inflow is assumed to remain constant over the planning period. Since most wastewater discharges will increase during this time period, the $7Q_{10}$ low flow in the year 2000 is grater by the amount of this increase. Groundwater contribution to the stream flow is distributed throughout the basin in proportion to the drainage area contribution to the stream along the length of its channel.

3. Ultimate carbonaceous CBOD is assumed to be 1.5 times the $CBOD_5$. This ratio may be changed if data indicates a different value would exist for a particular treatment process or waste characteristic.

4. Average stream temperature and pH is assumed to be approximated by the following table unless impacted by a thermal type discharge. This table represents monthly average values from ambient monitoring data contained in the EPA STORET data system.

Table IV-5
Statewide pH and Temperature Values

Month	pH	Temp °C
Jan	7.8	0.6
Feb	7.7	1.2
March	7.9	4.3
April	8.1	11.7
May	8.1	16.6
June	8.1	21.4
July	8.1	24.8
Aug	8.2	23.8
Sept	8.0	22.2
Oct	8.0	12.3
Nov	8.1	6.0
Dec	8.0	1.6

5. In order that the reaeration rate constant be applicable to wintertime ice conditions, the amount of ice cover on the stream is estimated. It is assumed that the effective amount of aeration should be inversely proportional to the percentage of ice cover. The winter reaeratior rate constant for each reach of the stream was then determined by multiplying

the temperature corrected rate constant by the adjusted fraction of open water in the reach. From experimental data the adjusted fraction of open water in the reach is equivalent to approximately one minus one half of the percent of ice cover (1-.5 x % ice cover).

Ice cover estimates were based upon general climatological conditions for the basin and upon field observations. Complete ice cover was assumed to be noncoincidental with the $7Q_{10}$ low flow. The percent of ice cover used for winter conditions in the computer analysis ranged from zero percent to 95 percent.

6. Since limited data is available describing each individual wastewater treatment facility's effluent dissolved oxygen concentrations, the following values were assumed for each class of wastewater dischargers:

Discharge limitations	Summer DO (mg/l)	Winter DO (mg/l)
Secondary Treatment	3.0	4.0
Advanced Treatment	5.0	6.0
Aerated Effluents	6-8	6-8
Industrial Plant	Each Discharge Handled Individually	

7. From analysis of available effluent data it has been assumed that a well operated and maintained secondary treatment plant should be able to achieve 10-15 mg/l and 15-20 mg/l of ammonia nitrogen under summer or winter conditions, respectively.

8. Best practicable or available technology effluent limitations described by EPA guidelines were used for industrial dischargers when available and sufficient. Otherwise, the actual allowable wasteload required to meet

stream standards is determined and identified as the wasteload allocation for that discharger. For municipal and industrial discharges with toxic parameters on streams classified as only general use, the allowable wasteload will be based on data contained in the U.S. EPA 304(a) criteria documents to determine instream toxic criteria. Calculations will follow the procedures presented in the Mixing Zone section item 2 (Toxic Conditions) of this chapter).

9. Water quality of tributaries (without wastewater sources) discharging to the streams being modeled was assumed to have saturated dissolved oxygen concentrations, an ultimate CBOD concentration of 6.0 mg/l and an ammonia nitrogen concentration of 0.0 mg/l in the summer of 0.5 mg/l in the winter.

10. Values of 4.0 mg/l, $CBOD_5$; 0.0 mg/l (summer) and 0.5 mg/l (winter) ammonia nitrogen; and 2.0 mg/l dissolved oxygen concentration were assumed as the water quality of the groundwater contribution.

11. Mixing of wastewater and tributary flows with the main body of water are site specific and calculated by the mixing zone equations noted in the Section. Mixing is not assumed to be complete and instantaneous.

12. Uniform lateral and longitudinal dispersion (plug flow) was assumed for the stream constituents as they move downstream.

Wasteload Allocation Procedures

The wasteload allocation procedures section is divided into two subsections, conventional pollutants and toxics. This division is necessary because the Water Quality Standards (Chapter 62) require different instream conditions or criteria to be met at different locations in the receiving stream.

A. Conventional Pollutants. The calculation of a wasteload allocation for conventional pollutants will consider the instream dissolve oxygen impacts of carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, or any other oxygen demanding material. The wasteload allocation for ammonia nitrogen and possibly some other oxygen demanding materials is also addressed in the Toxics section, as these pollutants are also defined as toxics. It should be noted that this section of the wasteload allocation procedures does not consider other types of conventional pollutants, such as suspended solids, pH, temperature, or oil and grease.

The wasteload allocation of the oxygen demanding pollutants are determined directly from the results of water quality models which account for the fates of the pollutants as they move down the receiving stream.

The use of the two water quality models, QUAL-II and Modified Iowa, for determining wasteload allocations now requires additional data on algal kinetics and is limited to short stream reaches. Due to a lack of algal kinetic rate constants on many stream reaches, the extensive number of designated stream reaches in Iowa and other factors, a sequencing or screening approach is being used to arrive at the final wasteload allocation (WLA). The sequencing of calculating a WLA is divided into three different steps, hand calculations, use of the Modified Iowa model, and use of the QUAL-II model. Any WLA, new or recalculated, for any continuous discharging treatment facility is determined following the sequence. Requests for a WLA will be handled as soon as possible. However, if a back log begins to occur, all requests will first be hand calculated (if necessary). This should address at least 50% of all requests. The remaining will next be modeled with the Modified Iowa program and finally by the QUAL-II, if required.

1. Hand Calculations

The use of hand calculations are intended to provide a quick method to determine if a CBOD discharge of standard secondary or BPT/BAT from the treatment facility is causing a water quality violation. This step could be skipped if it is causing a water quality violation. This step could be skipped if it is felt that the facility obviously would require advanced treatment. This calculation as with the use of the water quality models, will be performed using the $7Q_{10}$ stream flow or protected flow, the treatment facilities design dry weather flow (if applicable) and the appropriate standard secondary $CBOD_5$ and assumed ammonia levels. With the alternative treatment limits allowed in the definition of standard secondary, the specific permitted $CBOD_5$ levels for the selected (or expected) type of treatment must be used in the hand calculations. This hand calculation approach uses a conservative assimilation rate of $CBOD_5$ (20 lbs/d/cfs) which has been derived from past modeling results.

a. Available Stream Capacity

Staff will calculate the available stream capacity for $CBOD_5$ below the discharger in question by the fo`lowing relationships.

For $CBOD_5$

$$(Qu + Qd)\ 20.0\ \text{lbs/d/cfs} = CBOD_L$$

where:

$Qu = 7Q_{10}$ stream flow (cfs)
Qd = Dry weather design discharge flow (cfs)
$CBOD_L$ = Stream capacity carbonaceous BOD_5 (lbs/day)

The loading from the treatment facility at its specific standard secondary level is given by the following equation.

b. Treatment Facility loadings

For BOD_5

$$(CBOD_5)(8.34)(qD) = CBOD_e$$

where:

$CBOD_5$ = Permitted standard secondary $CBOD_5$ (mg/l)
Qd = Dry weather discharge flow (mgd)
$CBOD_e$ = Carbonaceous BOD_5 in the effluent (lbs/day)

c. Stream Capacity vs. Effluent Loading

If the stream $CBOD_5$ capacity ($CBOD_L$) above is larger than the effluent standard secondary $CBOD_5$ ($CBOD_e$), the stream is termed effluent limited for CBOD and no additional modeling is required. The effluent limitation for $CBOD_5$ will be the level set for standard secondary.

If the above comparisons finds the stream not to be effluent limited, the stream would require modeling using the Modified Iowa model. Additionally, unusual factors or stream conditions might warrant undertaking the next calculation step even if the stream is effluent limited. These unusual conditions might include: several dischargers within close proximity, discharge of large algal concentrations, discharge of elevated ammonia nitrogen levels and loadings to the stream at or near stream capacity.

2. Use of Modified Iowa Model

For those treatment facilities found not to be able to discharge at a standard level, staff will set up and run the Modified Iowa model described above. For most dischargers,, the previous model runs (run streams) of 1976-1982 can be used as the basis input data. Minor modifications in data formatting are required to incorporate the new algal relationships. The Modified Iowa program will only be used on the stream reach below the discharge, not the entire river basin.

For each discharger, a spring/fall, summer and winter run normally will be made using the same dry weather design flow as used in the hand calculations above. These multi-seasonal runs are necessary because of the potential seasonal ammonia nitrogen wasteload allocations developed in the Toxics sections. It is necessary to calculate the toxics based wasteload allocation for ammonia nitrogen for use in the modeling of conventional pollutants. In many instances, the protection of the ammonia acute and chronic criteria will be more restrictive than the oxygen demand exerted by the ammonia.

Previously calibrated rate constants and literature values found in Table IV-1 will be used for the modified model. Detailed calibrations will be carried out only for the QUAL-II model. The use of the modified model is to be a quick modeling exercise with minimum staff time. Reiterative model runs will be made varying effluent $CBOD_5$ from standard secondary, and NH_3-N to more stringent levels until model responses shows that dissolved oxygen water quality standards are met in the designated reach.

If the modeling demonstrates that standard secondary will meet water quality standards, then that level will be the effluent limits for the treatment facility. If the modeling shows that advanced treatment is required, then the stream reach will be modeled using the QUAL-II program to determine final wasteloads allocations.

3. Use of the QUAL-II Model

For those treatment facilities found not to be able to discharge at a standard secondary level as evaluated by the above two calculations, then staff will set up and run the QUAL-II model described above. As with the Modified Iowa model, QUAL-II will be run only on the stream reach below the discharger. It is within this short reach that the steady state assumptions used in the model are valid.

Setting up the run stream under QUAL-II format requires additional staff effort. However, some of the physical stream data found in the Modified Iowa model's run stream will be used with the QUAL-II run stream. Whenever possible, calibrated rate constants will be used. These calibrated values can come from data obtained from intensive stream surveys on the receiving stream, from calibration data on similar streams or from literature values shown in Table IV-4. The same dry weather design flow and ammonia nitrogen values will be used, as above.

For each discharger, spring/fall, summer, and winter model runs normally will be made varying the effluent $CBOD_5$ (and NH_3-N if necessary) until the model response shows that dissolved oxygen water quality standards are met in the designated reach. The final wasteload allocation will be the combination of $CBOD_5$ and NH_3-N which just meet the standards.

Specific NH_3-N limitations will be noted in the WLA up to the standard secondary range mentioned above (15 mg/l summer and 20 mg/l winter and spring/fall). This will indicate the available stream capacity for NH_3-N and allow for careful design of nitrification facilities. $CBOD_5$ limitations will be noted as carbonaceous or inhibited values except for certain industrial facilities for which BPT/BAT limits are expressed as BOD_5. An attempt will be made to establish a $CBOD_5$ to BOD_5 relationship for each industry for use only in modeling of the stream's assimilative capacity.

B. Toxic Parameters. The wasteload allocation for toxics parameters will not require the use of the two above mentioned models. However, it is necessary to determine the characteristics of the regulatory mixing zone and zone of initial dilution (ZID). The regulatory mixing zone will be determined from data supplied by the applicants, or from use of the mixing zone model noted in the Appendix, Mixing Zone Characteristics. Department staff will use stream characteristics obtained from file information unless additional data is provided by the applicant which demonstrates that the characteristics of the outfall or the discharge location do not match the assumptions used in the development of this model. Other models will be used where appropriate or as they become available.

The Appendix presents the basic field data requirements of a mixing zone study to be provided by an applicant for recalculation of the local mixing zone. The purpose of the recalculation is to more closely approximate the local mixing zone using site specific data instead of statewide data. Contact should be made with the department's Water Quality Planning Section prior to beginning any field study.

The calculations of toxic wasteload allocations involves the incorporation of the 'regulatory' mixing zone and zone of initial dilution for each wastewater treatment facility, the design effluent flow rates, and the applicable acute and chronic water quality criteria. The determination of the mixing zone and zone of initial dilution are presented in a separate section. This Toxics section uses these defined zones and the corresponding flow in establishing the wasteload allocations for toxics.

1. Calculations: As noted in Subrule 61.2(4) of the Water Quality Standards, the chronic criteria must be met at the boundary of the mixing zone and the acute criteria must be met at the boundary of the zone of initial dilution. The method for meeting these boundary conditions will be to use a simple mass balance of the pollutants.

$$(Q_z - Q_d)\ (C_u) + Q_d\ (C_d) = Q_z\ (C_s)$$

where:

Q_z = Stream flow in the mixing zone or zone of initial dilution (cfs)

Q_d = Discharge flow (cfs)

C_u = Background concentration (mg/l)

C_d = Discharge wasteload allocation (mg/l)

C_s = Applicable water quality standard (mg/l)

This equation is solved for C_d, with the results being a wasteload allocation for the protection of the acute criteria and a wasteload allocation for the protection of the chronic criteria. The wasteload allocation value is then carried forward to the Permit Derivation Procedures section.

C. Ammonia Nitrogen: Special consideration must be given to the calculations for a wasteload allocation for ammonia nitrogen. First, water quality standards list the ammonia criteria as a function of pH and temperature because of the influence these parameters have on the toxic form of ammonia (unionized). Therefore, it is necessary to establish the applicable 'average' instream pH and temperature values of the designated stream segment receiving the effluent before the acute and chronic ammonia criteria can be selected.

Second, the mixing zone flow and the zone of initial dilution flow are a function of the dilution ratio of the receiving stream to the effluent. This dilution ratio is defined in Chapter 60 of the department rules for a specific discharger as the ratio of the 7Q10 stream flow to the effluent design flow.

1. Dilution Ratios. The discharger will be separated into one of three types dependent upon the river and discharge flows:

   (1) Types 1: The ratio of stream flow to discharge flow is less than or equal to 2 to 1.

   (2) Types 2: the ratio of stream flow to discharge flow is less than or equal to 5 to 1 and greater than 2 to 1.

   (3) Type 3: the ratio of stream flow to discharge flow is greater than 5 to 1.

2. Mixing Zone Boundary pH and Temperatures. For all of these types, the pH and temperature used to calculate the water quality standards for the boundary of the mixing zone are defaulted to the statewide background values (for statewide values, see Table IV-5) unless local values or regional values are provided by the discharger.

(1) Local Values: If the applicant desires that local values be used, they must supply a minimum of 72 sets of hourly pH and temperature readings for each of the three seasons of the year. Preferably the readings will be obtained during the lowest flows during these periods and typical of 24 hour conditions. Monitoring values may be obtained either from upstream of the outfall and the discharge or from the approximate location of the downstream limits of the ZID and the Mixing Zone.

(2) Regional Values: If a facility, at reasonable distance upstream of the applicant, has supplied background readings of pH and temperature which the department believes can be used as background, these readings will be used instead of the statewide averages. Normally readings at the end of an upstream facilities mixing zone will not be used as background for the facility unless these are from close proximity to the applicants outfall.

3. Zone of Initial Dilution Boundary pH and Temperatures. The acute water quality criteria for ammonia will be based upon one of three methods for the three types of dilution ratios.

(1) For Type 1 facilities, the acute water quality criteria for ammonia will be calculated based on the effluent pH and temperature values.

(2) For Type 2 and 3 facilities, the acute water quality criteria for ammonia will be based on a pH calculated using the following equation.

$$\text{ZID pH} = 10^{\{(\text{LOG(background pH)}+\text{LOG(discharge pH)})/2\}}$$

$$\text{TEMPERATURE} = \frac{(BF * BT + DF * DT)}{BF + DF}$$

BF = Background Flow in ZID (cfs)

BT = Background Temperature (°C)

DF = Discharge Flow (cfs)

DT = Discharge Temperature (°C)

(3) From actual field data gathered during the mixing zone study, discussed above, (1) Local Values.

4. Mixing Zone and ZID Flow. The flow used in the wasteload allocation calculations for the mixing zone and zone of initial dilution vary with the type of dilution ratio.

(1) Type 1: The river flow included in the mixing zone flow will be 100 % of the 7Q10 river flow. The river flow included in the zone of initial flow will be 5% of the river flow.

(2) Type 2: The 7Q10 river flow included in the mixing zone flow will be 50% of the river flow. The river flow included in the zone of initial flow will be 5% of the river flow.

(3) Type 3: The 7Q10 river flow included in the mixing zone flow will be 25% of the river flow. The river flow included in the zone of initial flow will be 2.5% of the river flow.

5. The calculation of the wasteload allocation uses the relationship:

$$(Q_z - Q_d) * C_u + Q_d * C_d = Q_z * C_s$$

where:

Q_z = Stream flow in the mixing zone or zone of initial dilution (cfs)

Q_d = Discharge flow (cfs)

C_u = Background Concentration (mg/l)

C_d = Discharge wasteload allocation (mg/l)

C_s = Applicable water quality standard (mg/l)

This equation is solved for C_d, with the results being a wasteload allocation for the protection of either the acute or chronic criteria. The most stringent wasteload allocation value is then carried forward to the Permit Derivation Procedures section.

6. Where visible dye studies have been done, the ammonia WLA calculations will use the mixing zone flow contained in the visible dye plume. If an analytical Fluorometer dye study is performed, the study results projected to the 7Q10 flow regime will be used to calculate the mixing zone flow. This mixing zone flow will be that value associated with diluting the effluent concentration to the maximum dye concentration at the mixing zone boundary. This is the required stream flow necessary to assure that the water quality standards are not exceed at any location across the mixing zone boundary.

Once these ammonia values are determined, the above mass balance calculations or the use of ammonia decay relationship and algal uptake can be used to arrive at the applicable ammonia nitrogen wasteload allocations. The ammonia decay and algal uptake equations used in the modified Iowa model will account for the limited loss of ammonia in the mixing zone. These equations will be used when a WLA indicates an ammonia limit more stringent than secondary treatment. Using the allowed stream flow of the zone of initial dilution, the WLA calculations will assure that the acute criterion is met. Using the dilution of the flow contained in the mixing zone and the loss within the mixing zone, the WLA will assure that the chronic criterion is met.

D. Total Residual Chlorine. Total residual chlorine (TRC) effluent limits will be calculated for any wastewater treatment facility discharging TRC into or impacting one of the four Class B waters. The applicable stream standard criteria are listed in Table 1 of Chapter 61.

a. Background Levels

The calculations for TRC effluent limits must incorporate any background levels of TRC. Very limited water quality data exists on background TRC levels and in most cases the level will be assumed to be zero.

b. Calculations

Two types of calculations are available for determining effluent limits: hand calculations, noted above for toxics, and time dependent decay of TRC. For facilities discharging TRC directly into or within one-fourth mile of a Class B water, hand calculations for toxics should be applied. For facilities off the Class B segment, the decay model should be used. In some cases, the decay model may be used to show impacts between two dischargers in close proximity. Most calculations will use the hand calculation for toxics method.

1) First Order Decay

The decay model uses a standard first order expression in which time of travel in the stream is incorporated into the calculations. Using the model expression noted in EPA's "Technical Guidance Manual for Performing Wasteload Allocations; Book 2, Chapter 3, Toxic Substances" June 1984, Appendix D, the TRC decay equation becomes:

$$C_t = (C_m)\ e^{-kt} \tag{5}$$

Where:

$C_m = (C_b\ Q_b + C_o\ Q_o)/(Q_o + Q_b)$

C_t = TRC concentration at time t, ug/l

C_b = Background TRC concentration in Class B stream, ug/l

Q_b = Stream flow in the mixing zone, zone of initial dilution, or general class stream, cfs

C_o = WLA TRC concentration, ug/l

Q_o = Effluent flow, cfs

k = Decay rate constance, day^{-1}

t = Time of travel in modeled reach, day

Solving for C_o

$$C_o = [C_t\ e^{kt}\ (Q_o + Q_b) - C_b\ Q_b]/Q_o$$

The normal use for equation 6 would be to first determine the applicable TRC concentration "C_t" at the first Class B stream reach. "C_t" is the applicable acute or chronic criteria if the Class B stream is a continuation of the same stream receiving the discharge. If the discharger is off on a tributary to the Class B stream or if a major tributary is encountered prior to the Class B reach, "C_t" must be calculated based on the dilution within the Class B reach. Dischargers to a general class segment of the Class B stream use 100% of the $7Q_{10}$ at the upper most Class B segment for dilution. For facilities discharging into a tributary to the Class B stream, the flow contained in the regulatory mixing zone and zone of initial dilution in the Class B segment would be used for dilution.

The next step would be to determine "t", the time of travel (in days) from the outfall to the Class B segment.

The rate constant "k" can be calibrated from Iowa stream data, if available, or from literature values. The above referenced TRC document notes a value of 100 day^{-1} (or greater) found on a slow moving warm water stream similar to Iowa rivers of less than 500 cfs. Very limited field data has been gathered to date due to the difficulty in field measurement of TRC at low instream concentrations. A value of 20 day^{-1} should be used unless site specific data is available.

E. Fecal Coliform: Fecal coliform effluent limits will be calculated for any wastewater treatment facility discharging directly into or impacting a Class A water. The applicable stream standard for Class A waters is 200 organisms/100 ml (Chapter 61.3(3)a(1).

1. Background Levels: To assure compliance with this standard, all calculations will incorporate background fecal coliform levels associated with nonrunoff periods. Available STORET data will be used to determine the background levels (the 50th percentile value of all non-runoff influenced data points at the sampling site.) For some streams there may

not be enough data to provide valid numbers. In these cases, data from a similar stream, having similar upstream pollution sources, will be used. Historic review of existing data from above wastewater facilities indicates that the background fecal coliform levels on key Class A streams usually equal or exceed the Class A standard of 200 org./100 ml.

2. Calculations: Two types of calculations are available for determining effluent limits: hand calculations and first order decay. For treatment facilities discharging directly into or within one-half mile of the Class A stream, hand calculations should be applied. For treatment facilities off the Class A stream, the decay model should be used. In some cases, the decay model may be used to show impacts between two discharges.

a. Hand Calculations

Hand calculations use a basic mass balance relationship incorporating upstream $7Q_{10}$ stream flow, discharge flow and upstream fecal coliform levels.

$$C_u\, Q_u + C_D\, Q_D = (Q_u + Q_D)\, 200$$

Where:

C_u = Background fecal coliform level, # organisms/100 ml

Q_u = Flow in mixing zone, cfs

Q_D = Discharger average dry weather flow, cfs

C_D = Discharger fecal coliform level, # organisms/100 ml

To obtain the discharge fecal coliform level (C_D) the equation is rearranged, so that:

$$C_D = ((Q_u + Q_D) + 200 - C_u\ Q_u)/Q_D$$

Note that in no case can the effluent limits be more restrictive than 200 organisms/100 ml.

b. First Order Decay

The decay model uses a traditional relationship in which time of travel in the stream is incorporated into the calculations. Using the model formulated in the EPA publication "Rates, Constants and Kinetics Formulation in Surface Water Quality Modeling" (Second Edition), June 1985, the equation used is as follows:

$$C_t = C_m\ e^{-kt}$$

where:

$C_m = (C_b\ Q_b + C_o\ Q_o)/(Q_o + Q_b)$

C_t = Coliform concentration at time t, # organisms/100 ml

C_b = Background coliform concentration in non-Class A stream, # organisms/100 ml

Q_b = Background stream flow, cfs

C_o = WLA coliform concentration, # organisms/100 ml

Q_o = Effluent flow, cfs

k = Die=off rate constant, day^{-1}

t = Time of travel in modeled reach, day

To solve for C_o the above equation is organized to:

$$C_o = (C_t\ e^{kt}\ (Q_o + Q_b) - C_b\ Q_b)/Q_o$$

The normal use of Equation 3 would be to first determine applicable fecal coliform concentration "C_t" at the lower most stream segment (prior to becoming Class A). "C_t" is 200 organisms/100 ml if the stream segment is the same stream as the Class A segment. If the stream segment is a tributary to the Class A segment or if a major tributary is encountered prior to the Class A segment, "C_t" must be calculated based on the dilution within the Class A segment. See 2.a. above to determine the mass balance relationships for calculating "C_t" or C_d.

The next step would be to determine "t" time of travel (in days) from the outfall to the Class A segment. This usually will be based on the distance (feet) to the Class A segment divided by the average velocity (ft/sec) at low flow. Stream velocities vary with each segment; however, typically, they range from .1 to .5 feet per second.

The rate constant "k" can be calibrated from Iowa stream data, if available, or from literature values. The EPA reference indicates rate constants from .96 day^{-1} to above 6.0 day^{-1}. The EPA document notes that 90% of rate constants are below 5.28 day^{-1}. This later value should be used unless other Iowa based constants are available.

As an example, assume a city is five miles upstream from a major Class A stream; Class A stream flow, 50 cfs; tributary stream flow, 10 cfs; discharger flow, 2cfs; stream velocity, .2 fps; background fecal coliform, 50 organisms/100 ml in tributary and, 70 organisms/100 ml in Class A segment.

$$Ct = \frac{(62 \text{ cfs})\ 200 - 50 \text{ cfs}\ (70)}{12}$$

$$= 742 \text{ organisms/100 ml}$$

$$t = \frac{(5 \text{ miles})\ (5{,}280)}{.2 \text{ fps}\ (86{,}400 \text{ sec/day})} = 1.53 \text{ days}$$

$$\text{then, } C_o = \frac{[742\ e^{5.28(1.53)}]-70(10)}{2} = 1.43 \times 10^7 \text{ organisms/100 ml}$$

Therefore, this city could discharge up to 1.43×10^7 organisms/100 ml without exceeding the WQS in the Class A segment.

F. Stream Considered Under the General Criteria

The water quality standards specifically mention seven criteria which apply to all surface waters (61.3(2)). These criteria have been considered in setting the standard for those streams in one of the six designated uses. In waters not in one of the six designated uses, these seven criteria must still be met.

Of particular importance in setting wasteload allocations is the criterion (61.3(2)"d") which states that waters must be free of any substance which is acutely toxic to human, animal or plant life.

The nature of streams covered only by the seven general criteria vary widely. The stream being evaluated may be a perennial stream or an intermittently flowing channelized drainage ditch. Each flow regime and habitat has its own resident species present and the specific acutely toxic levels can only be determined with a case by case evaluation. Some of the items which are considered in an evaluation are the applicable flow regime, resident species present and acutely toxic levels associated with those species.

In order that acutely toxic conditions are not exceeded in the stream the concept of extablishing a no-effect level or LC_0 is introduced. The LC_0 is determined by calculating the value of 1/2 the 96 hr LC_{50} for the most sensitive resident species.

The establishment of a protected flow - that stream flow regime at which the critical resident species of the aquatic organisms which may reside in the stream will be present - is done using a similar approach to that used to set protected flows for Class B streams. For many general streams their intermittent nature will not support a viable aquatic life. Therefore, a case by case determination of the flow regime will be made based on: the amount of discharge from wastewater treatment facilities; the reoccurrence of low flow; minimum flow necessary to support the normally occurring aquatic species and the season. Typically a flow regime of 1 to 2 cfs would support the resident aquatic species during summer and winter periods.

The evaluation of resident aquatic species should include species found during the critical low flow periods not those species found during spawning, (higher flow) periods when adequate dilution occurs. Once the resident species are established (or projected), the LC_o or 96 hr LC_{50} values are obtained for the species from the EPA documents, "Ambient Water Quality Criteria for (the toxic of concern)", Table 3. From the toxicity data contained in these documents, the most sensitive specie and associated concentration would be considered as the water quality criterion used in the following mass balance equation.

$$C_u Q_u + C_D Q_D = (Q_u + Q_D) \frac{WQC}{2}$$

where:

C_u = Background pollutant concentration, mg/l

Q_u = $7Q_{10}$ in the general classified segment (about the outfall), cfs

C_D = Wasteload allocation for the pollutant of concern, mg/l

Q_D = Discharge flow, cfs

WQC = Genus Mean Acute Value for most sensitive species in receiving stream, mg/l

Solve the equation for C_D. This value will be compared to the acute and chronic wasteload allocation calculated in the previous Toxics section. The most stringent of the wasteload allocations will be used in the Permit Derivation Procedure section.

Minimum Protected Flow Policy Statement

The department will use the exception clause in Section 61.2(5) (departmental rules) to develop wasteload allocations for dischargers on intermittent and low flow streams. The department will establish a minimum protected flow for the calculation of wasteload allocations in selected Significant Resource and Limited Resource streams where it has been determined that the aquatic resources of the receiving waters are of limited significance at flows less than the established minimum. The use of minimum protected flows to calculate wasteload allocations on intermittent and low flow streams will supersede the use of the $7Q_{10}$ stream flow. Calculation of wasteload allocations will still use the procedures described previously.

Only the Significant Resource and Limited Resource stream segments with a natural background low flow ($7Q_{10}$) of less than 2 cfs will be considered for establishing a protected flow. For the low flow streams, DNR Fish and Wildlife Division staff members will evaluate the fisheries' potential and other related aquatic organisms in the stream at the $7Q_{10}$ flow. The staff evaluation of the aquatic resources of low flow streams would place the streams in one of three categories:

Category 1: The first stream category would be typical meandering to channelized streams with silt to silt/sand beds in which water temperature equaled or exceeded 32°C during low flow periods. At this low flow condition most higher tropic aquatic life has moved to deeper pools or to the main stream reaches. Thus aquatic life for which the design use was considered for, would not be present in significance numbers in the stream.

Category 2: The second stream category would consist of reaches where the background flow originated largely from spring or bedrock outcrops. Stream beds consist of silt/sand to sand and gravel. The stream temperature may range between 20° to 32°C with high tropic level aquatic life staying in the stream reach in small pools and underbank cuts.

Category 3: The third stream category would consist of reaches capable of supporting cold water aquatic organisms. Stream flow originates from springs with water temperatures less than 20°C. Stream bends consist of sand to sand and gravel. These stream reaches may be classified as cold water or tributaries to such stream reaches.

For those stream reaches under the first category staff will recommend the specific protected flow level for each stream reach. This value may range from 1 to 2 cfs of natural background flow depending upon the normal aquatic organisms inhabiting the reach. Protected stream flows higher than 2 cfs would be considered if unique conditions have limited the normal aquatic organisms from inhabiting the stream reach at 2 cfs. Such conditions as depth of water, temperature, velocity, substrate may be considered. Careful documentation on such limiting conditions will be made by department staff. For the second category streams, a protected flow of 1 cfs or less may be allowed. For the third category of streams, no protected flow will be used to calculate the wasteload allocation.

The effluent limitation, including ammonia, for any domestic discharger would be based upon this protected flow level of natural background flow added to any discharge flow originating from a point source discharger.

The protected flow level will only be required along downstream reaches until the naturally occurring $7Q_{10}$ level was demonstrated to be greater than the protected flow level as determined above, or a significant source of stream flow entered the reach to support the designated aquatic uses. The establishment of protected flows will not apply to facilities that discharge to High Quality Resources waters.

FLOW VARIABLE AMMONIA LIMITATIONS PROCEDURES

Purpose

To provide domestic wastewater treatment facilities, designed to provide advanced treatment, the option of discharging higher concentrations of ammonia as the stream flows increase without causing impacts to the receiving stream's biological communities or violating water quality standards.

Procedure

This procedure will provide guidance to department staff on which treatment facilities could be considered for variable ammonia limits, the rationale for the basic requirements and the methodology to calculate specific limitations.

This procedure will be considered for domestic treatment facilities designed and constructed to remove ammonia nitrogen. Flow variable ammonia limits procedures for industrial facilities will be considered separately. The domestic facility must demonstrate to this department its ability to meet design ammonia effluent limits or wasteload allocation (WLA) under all climatic conditions. It is important to be able to achieve WLA levels during winter conditions because of the sensitivity of nitrification units to cold temperatures. Also, most low flow conditions occur during winter periods.

Depending on the design flexibility of the nitrification units (number of basins, piping, monitoring equipment, etc.), the methods to achieve flow variable ammonia limits must be tested and mastered by the operator. The facility must be able to establish a consistent recovery time from no or partial nitrification to complete nitrification under various temperature conditions.

Since the calculations for flow variable ammonia limits rely heavily on stream flow, it is important that a stream gauge upstream of the treatment facility be available to provide daily stream flow readings. The gauge should be near enough to the treatment facility to accurately represent the stream flow at the outfall.

The specific effluent limits are determined by department staff by first calculating instream acute and chronic total ammonia nitrogen criteria applicable to the designated stream uses then applying the preceding wasteload allocation procedures. The flow variable calculations will consider incremental increases in stream flow while following the same wasteload allocation procedures, including, recalculation of mixing zone flows at the increased stream flows. Additional observations of the stream at higher flow rates may be required by the department.

MIXING ZONE PROCEDURES

Objective

The objective of this procedure is to provide guidance on the methods to be used in considering a mixing zone while determining applicable effluent limitations for a wastewater discharge.

Background

Chapter 61.2(4) of the department's water quality standards provide for defining the mixing zone of a wastewater discharge. It is at the downstream edges of the zone of initial dilution and the mixing zone that the water quality standards are to apply. The standards contain specific criteria and considerations which are to be used in determining the extent and nature of a mixing zone. The most restrictive of the provisions establishes the mixing zone dimenisions and flow. The following is a summary of the key provisions of the standards, additional policies and the sequence used in defining the regulatory mixing zone and zone of initial dilution.

1. The maximum flow in the mixing zone for toxic parameters will be set as 25% of the 7Q10 for interior streams, Big Sioux River, Des Moines River and the Mississippi and Missouri Rivers. The maximum flow in the mixing zone for ammonia is discussed on page 53.

2. In addition, the flow in the mixing zone will be restricted by natural boundaries of mixing, such as islands, semi-permanent sandbars, and manmade obstructions, which limit how much water can mix with the discharge effectively. How these limits affect the regulatory mixing zone are:

   a. For rivers which fall under 1. above, we will use 25% of the portion of the flow in the main or side channel into which the facility discharges or the mixing zone travels, where that flow is separated from flow in the other channels of the river by sandbars or islands which have remained in place for more than three years.

3. Length of the mixing zone may not exceed the most restrictive of the following seven conditions:

   a. The distance to the juncture of two perennial streams.
   b. The distance to a public water supply intake.
   c. The distance to the upstream limits of a heavily used recreational area.

d. The distance to the middle of a crossover point in a stream where the main current flows from one bank across to the opposite bank.

e. The distance to another mixing zone.

f. A distance of 2000 feet.

g. The location where the mixing zone contained the percentages of stream flow noted in one and two above.

4. The length of and flow in the zone of initial dilution for toxics may not exceed 10% of the mixing zone values. For ammonia, the length and flow of the zone of initial dilution is discussed on page 54.

The chronic criteria for toxics and ammonia nitrogen will be met at the boundary of the mixing zone. The acute criteria for toxics and ammonia nitrogen will be met at the boundary of the zone of initial dilution. Although not specifically discussed in the standards, the effects of the biological oxygen demand (BOD) are not expected to be observed until after the end of the regulatory mixing zone. This is because the movement of water through the mixing zone normally will occur faster than the biological uptake of oxygen due to the BOD.

These two zones will be determined in one of two manners, by actual field measurements at low stream flow conditions or by use of a dispersion model. It is the goal of the department to obtain all necessary information of these zones from the information submitted in a wastewater treatment facility's NPDES permit application. A field procedures protocol is being developed which will be used by a NPDES applicant to obtain actual field data. Until data is submitted as part of the NPDES permit application, the limited field data obtained at a few sites by EPA, University Hygienic Laboratory and the department staff and the use of the dispersion model will be the only means to determine these zones.

Calculations

When conditions at the discharge violate model assumptions, the mixing zone model used by the department staff is a Far Field Plume Model. The model equations use the predicted or observed stream width, average stream depth, average stream velocity and channel slope to develop through the use of a lateral dispersion coefficient and shear velocity relationship, a prediction of the mixing zone size and flow. A copy of the model program on Lotus 123 software is available from the department. Further information on the equations used is shown in the Appendix. Where data warrants its use, a more complex model using a Fortran code may be used. It also is available from the department. A list of models used by the department in setting wasteload allocations is available.

THERMAL DISCHARGERS

Numerous thermal dischargers impact Iowa rivers and streams. The significant thermal dischargers result from electric power generation facilities and industrial facilities requiring cooling of equipment or process systems. Specific instream temperature changes are noted in the water quality standards along with the requirement that the standards be met beyond the mixing zone. The complex nature of heat transfer and dispersion make accurate predictions of a thermal plume nearly impossible. However, there still is a need to calculate the expected temperature rise and the distance to recover to (near) initial conditions.

Several technical approaches are available to address the thermal impacts. Extensive evaluations have been performed under EPA effluent guideline requirements for electric generating facilities - Part 316(a). The results or findings of these studies will serve as the primary method for staff to evaluate thermal impacts. For locations where 316(a) information is not practical to apply, the following mathematical approach will be used by staff.

The temperature elevation after the stream and discharge flows have initially become well mixed is given by the following relationship. (Source: U.S. EPA, "Water Quality Assessment", pg. 451, eq. IV-66).

$$T_{wm} = (Q_p/Q_r)\ (T_e - T_r)$$

where:

T_{wm} = temperature elevation after initial well mixing (°F)

Q_p = flow rate of the cooling water (cfs)

Q_r = flow rate of river in mixing zone (cfs)

T_e = temperature of heated effluent (°F)

T_r = temperature of river above discharge (°F)

This relationship does not account for heat losses that occurs as the two flows become mixed. For interior streams, the value of T_{wm} should be equal or less than 3°C (5.4°F) as required in the Water Quality Standards.

Procedures are available from the EPA "Water Quality Assessment" document to calculate instream distances from the point of initial mixing until the stream temperature recovers to levels allowed by water quality standards. The mathematical relationships presented in the EPA document have not been verified for Iowa stream and river conditions. Several alternative calculation approaches should be considered along with data generated from Part 316(a) studies.

Example distance calculations can be found in the U.S. EPA "Water Quality Assessment" document on pages 423 to 461.

The mixing zone cross sectional area and volume discussion above also applies to the calculations for thermal dischargers. The reduction of the percent of river area or volume in the mixing zone (below the 25% requirement) for the Mississippi and Missouri Rivers has additional justification when the heated plume influences the highly productive fish habitat areas and identified clam beds often located along the stream bank or near bank areas.

PERMIT DERIVATION PROCEDURE

Introduction. This section of the Support Document describes the method used to translate a wasteload allocation into an NPDES permit limit. The procedures are applied to any discharger in the state, municipal, industrial, or semi-public, for which a water quality-based permit limit is required. The purpose of these procedures are to provide an effluent limit which will statistically assure that the wasteload allocation will not be exceeded due to the variations in facility operation, monitoring and parameter analysis. The more restrictive of the acute or chronic wasteload allocation will be used in the following calculations.

1. Simplified Procedure:

Maximum Permit Limit = Wasteload Allocation Concentration

Monthly Average Permit Limit = 0.67 X Wasteload Allocation Concentration

2. Statistical Based Procedure:

The Maximum Permit and Average Permit Limits will be calculated using the statistical procedure noted in the Appendix. This procedure will consider the required sampling frequency for each water quality based parameter noted in Chapter 63 of the department rules, and any known coefficient of variation (CV) for each parameter. This CV may be based on the individual treatment facility's operations or where the CV data is lacking a value of 0.6 will be used. If a wastewater treatment facility selects to increase the monitoring frequency, the corresponding permit limits will be calculated to reflect this increase frequency.

The more lenient of the permit limits from the two procedures will be the values included in the NPDES permit process. Technology based requirements must also be met.

REFERENCES

1. Streeter, H. W., and Phelps, E. B. "A Study of the Pollution and Natural Purification of the Ohio River. III., Factors Concerned in the Oxidation and Reaeration," Public Health Bulletin No. 146, U.S. Public Health Service, Washington, D.C. (1925).

2. Dougal, Baumann, and Timmons, "Physical and Economic Factors Associated with the Establishment of Stream Quality Standards," Volume No. 2, March, 1970.

3. Tsivolgou, E. C. and Wallace, J. R., "Characterization of Stream Reaeration Capacity," U.S. Environmental Protection Agency. EPA-R3-72-012, October, 1972.

4. Leopold, Luna B. and Maddock, Thos. Jr., "The Hydraulic Geometry of Stream Channels and Some Physiographic Implications," Geological Survey Professional Paper (#252), U.S. Government Printing Office, 1953.

5. U.S. Environmental Protection Agency, "Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants - Part 1," EPA-600/6-82-004a, September, 1982.

APPENDIX

Mixing Zone Studies

The following are the basic field data requirements for two types of mixing zone studies which are to be provided by an applicant for recalculation of the local mixing zone. The purpose of the recalculation is to more closely approximate the local mixing zone using site specific data instead of statewide data. Contact should be made with the department's Water Quality Planning Section prior to beginning any field study.

A. Simplified Mixing Zone Study.

1. Stream Characteristics. It should be noted that the terms low flow and low stream flow are used in the following discussion. These terms are not synonymous with the 7Q10 flow or protected flow. Stream surveys to gather mixing zone data should be collected as near to the 7Q10 or protected flow as is normally feasible during the summer months of the year. A normal limit of 5 times the 7Q10 or 2 times the protected flow is desirable for the observations. Stream flow conditions closer to the 7Q10 are desirable for those locations where normal flows during the year approach the 7Q10 or where the flows are controlled by impoundments.

   a. A description is needed of the stream upstream and downstream from the outfall at low flow, preferably include pictures. Include in the description, the following items for a distance of 2000 feet downstream (unless other distance limitation is known to apply) and 200 feet upstream of the outfall:

(1) Description of the stream bed material: sand, fine or coarse gravel, mud, or rock.

(2) Note pools and riffles, areas of uniform depths, estimate length and number thereof, and the rapidity of the variations; i.e., gradual, alternating occasionally, or alternating frequently.

(3) Describe the amount of weed growth and snags in the stream, in terms of negligible effects on the stream flow to severe effects on the stream flow.

(4) Describe the amount of meandering within the 2000 foot distance.

(5) Describe other features which might effect the mixing zone such as delta formation at the stream mouth, other discharges or perennial springs, etc.

b. A description of the outfall during a low stream flow period, include an indication of the discharge flow during the period being described, preferably include pictures. Describe such things as the size and configuration of splash pools, outfall height or depth, outfall diameter (if normally filled during discharging), and/or average velocity of flow exiting outfall when submerged.

c. Field data should include at least two cross sections of the stream at low flow, an upstream location and at the anticipated mixing zone. Each cross section should including a minimum of 10 depths measurements (depths taken at least every two feet if stream width is less than 40 feet and at least every 5 feet if less than 100 feet, otherwise every 10 feet). Stream velocities should be measured using a velocity meter. Three cross sections should be provided if the dilution ratio is less than 3:1, one upstream, one at the anticipated mixing zone, and one spaced evenly downstream of the outfall and the mixing zone. If there is several pools and riffles, additional cross sections are needed to provide a more accurate indication of average depths.

2. Instream Water Quality Data. Where the discharge is into a shallow or marshy area which has no clear channel or their is considerable backwater effects from a downstream dam or river, information should be obtained on the stream and discharge density and temperature. Information should be obtained in a similar manner to that stated in the Ammonia section. Information about collecting pH and temperature is contained in the Ammonia section.

B. Mixing Zone Studies Using Dye Injection.

An applicant may elect to provide additional filed data on the actual dispersion of their effluent into the receiving stream. This field data, if adequate, will be used in place of the departments data. The objective of the dye studies is to prove that a more rapid degree of mixing occurs due to local conditions (very high river complexity) than the degree of mixing assumed by the department. The normal type of dye study will be to characterize the visible dye plume. However, a more complex dye study may be considered where the dye concentrations are measured florometerically with the objective to project the maximum dye concentration at the boundary of the mixing zone and zone of initial dilution.

Dye studies should be performed under non-ice conditions. Non-ice conditions are considered to be worst case conditions for diffusion, though, they are possibly the conditions under which 7Q10 is reached. The maximum flow limits for all dye studies will be set by the department on a case by case basis. In general, 5 times the 7Q10 flow as the upper bound for a dye study will be selected. Where a protected flow is the flow used for the wasteload allocation, it is likely that the limit used will be 2 times the protected flow.

All dye studies require a department approved quality assurance plan and work plan.

1. The minimal dye study requirements are described below. This dye study, using visually determined mixing zone limits, should only be used where river complexity and outfall complexity is minimal. River complexity being low when there is: little meandering, even river depths and cross sections, few snags, or other causes of diffusion changes within the 2000 foot maximum distance for the mixing zone. For streams and rivers with complexity, the dye studies should follow the procedures noted in item 2 below.

If the mixing zone will be limited by one of the other length limitations noted in the rules, the features of the length limitation must be noted, including the distance to the limitation. The study should contain the following information:

a. Since different dyes may be used and river conditions change, the minimum concentration at which the selected dye is visible shall be reported. Methods for determining this may be refined and modified as they are improved, but, will require at least one quantitative analysis, and may require analysis of samples taken at one cross section of the stream.

b. Dye input to the discharge shall be such that it provides a fairly stable outfall concentration. Dye input to the river at other points downstream from the outfall, if required, shall be at a set rate. The input dye concentrations and discharge dye concentrations shall be indicated in the report.

c. Describe the lateral limits of visible dye in the stream at all distances up to 2000 feet, in most cases dye visibility will not reach 2000 feet. Methods for reintroduction of dye or measurements for determining the visible portion may vary and warrant discussion with department staff.

d. Discharge flow rates during the study. One stream flow rate during the study. Flow rates and depth-velocity profiles at preselected points in the plume. Depth-time record for the stream at a single location during the study.

2. Following are the requirements for dye studies for streams and rivers with significant complexity and do not meet the qualifications for the limited study described in 1, above.

a. Complete the activities in items 2 b and d, above

b. For at least six locations in the first 500 feet downstream of the outfall, the stream will be marked for sampling and plume depth-velocity profiles during the study.

c. An additional stream location will be marked for each additional 500 foot of distance downstream from the outfall.

d. Dye will be introduced into the discharge and permitted to stabilize in the river prior to sampling.

e. Samples at each of the locations marked under b. or c. above, will be taken at intervals across the stream chosen so that a good representation of the plume at each distance is obtained.

f. Other information may be required from the study as complexity of the mixing zone warrants.

Mixing Zone Calculations

The mixing zone dispersion model used by the department staff is based upon an equation obtained from EPA contractors involved with toxics modeling. This equation is a 'Far Field' analytical solution for mixing in a river where the discharge is uniformly mixed from top to bottom of the river. The original equation has been adjusted to incorporate a near shore discharge rather than a mid-channel discharge.

The Equation used is

$$C = \frac{Q_e * C_e * e^J}{2*d*K} \qquad (1)$$

where C = Concentration in the river at location x,y, mg/l;

C_e = Concentration of the Discharge, mg/l;

Q_e = Discharge flow in cubic feet per second;

d = average stream depth, feet;

u = average stream velocity, feet per second;

x = distance downstream from the discharge, feet;

y = distance from the discharge side of the shore, feet;

$$K = (\pi * D_y * u * x)^{0.5}$$

$$J = (-u * y^2)/(4 * D_y * x)$$

D_y = the lateral dispersion, square feet per second.

The lateral dispersion is found from the equation

$$D_y = \alpha * d * u_s \qquad (2)$$

where α = a proportionality variable which varies with the stream, it is normally about 0.6 + or - 0.2, but, it can vary from a value of 0.1 which has been found in experimental plumes to larger than 0.8 which has been found in natural channels. For most rivers in Iowa it is expected to be larger than 0.4, and will normally be assumed to be 0.6.

$$u_s = \text{the shear velocity} = (1/8 * f * u^2)^{0.5} \qquad (3)$$

f = the Fanning or Darcy-Weisbach friction factor, which can be found from diagrams in various references. Note: To facilitate the development of wasteload allocations an approximation for f was developed. The developed equation is not accurate for f at all Reynold's numbers or (e/d)'s. The equation is:

$$f = 4 * 0.01895 * (e/d)^{0.5} + 0.001701 \qquad (4)$$

e = is the size of the roughness of the channel. An equation was developed from limited experimental data which indicated reasonable fit to an equation for

$$(e/d) = 1/(L + 0.001 * Q_r + 2.6) \qquad (5)$$

$$L = 15{,}000^{1.2} * Q_r^{\,2}$$

Q_r = River flow rate in cfs.

Equation (1) is solved for C at varying x,y locations and rounded to five decimal places. The y locations where C equals zero are then taken to be the width of the plume. The flow in the plume at that point is calculated to be the plume width times the average river depth times the average river velocity.

The acute and chronic wasteload allocations are determined using the flow in the mixing zone (or zone of initial dilution) determined using the previous criteria, the discharge flow, the background concentration and the water quality standard. The equation for the wasteload allocation is

$$WLA = (C_s * Q_m - (Q_m - Q_e) * C_b)/Q_e \quad (6)$$

where C_s = the acute or chronic water quality standard;

Q_m = the zone of initial dilution or mixing zone flow;

C_b = the background concentration.

Inputs Into the Mixing Zone Calculations

Development of the flow, width, average depth, and average velocity used in the above equations is developed from a separate set of equations or actual field data. Where a cross section of the river and flow rate is known at or close to the point of discharge at a higher stage, the field obtained cross section and velocities are used along with slopes obtained from USGS topographic maps to determine Manning's n for the river at that flow. (If slope is measured in the field this may improve the quality of the information from these equations since significant differences in slope from the topographic map may occur). The equations used are

$$Q_r = W * d * u \quad (7)$$

W = Width of river

$$d = W / (W/d) \tag{8}$$

Where (W/d) = a ratio determined from the field data.

$$r_H = \text{Hydraulic Radius} = W * d / (2*W + 2*d) \tag{9}$$

Note: The hydraulic radius is actually a ratio of the area of stream cross section to the wetted perimeter of the stream and improvements in the equation used to obtain the hydraulic radius will probably improve the quality of the information from this set of equations. The above equation is based on the hydraulic radius for a rectangle given in Perry's Chemical Engineers Handbook 4th edition page 5-20.

$$u = 1.49/n * r_H^{(2/3)} * S^{0.5} \tag{10}$$

where n = Manning's n

S = Slope

The Manning's n and (W/d) ratio determined from the above equations are then adjusted to the 7Q10 flow using:

$$n_{7Q10} = n_{orig} * Q_r/Q_{7Q10} \tag{11}$$

$$(W/d)_n = (W/d)_{orig} * (Q_r/Q_{7Q10}) * (d/d_a) \tag{12}$$

where d_a = The average depth without the first and last reading in the cross section.

These are then used with the above equations to determine the average velocity and average depth of the river at the 7Q10. A line can then be plotted across the previous cross section which represents the new surface level. The new surface level is found using the old average depth minus the new average depth to change the location of the surface level. The method used has normally shown less than 10 percent difference between the length of the new line representing the new surface width and the calculated width of the river obtained using equation (7).

Where no field information exists it is difficult to predict the width, depth and velocity of a river since many variables influence these. The department will normally adjust W, (W/d), and n to predict a width, depth and velocity using equations (7), (9) and (10) to provide a range of acceptable numbers.

Iowa Permit Derivation Methods

The Iowa permit derivation methods, the simplified or the statistical based, are discussed below. The more lenient of the average and maximum permit limits from either of the procedures will be the recommended values for use in the permit process to assuring that water quality standards are met.

1. Simplified Procedure:

   Maximum Permit Limit = Wasteload Allocation (Acute or Chronic)

   Average Permit Limit = 0.67 x Wasteload Allocation

2. Statistical Based Procedure:

The statistical based procedure requires the following four input values to calculate the permit limits.

CV = Coefficient of Variation

MF = Monitoring Frequency, samples per month

AWLA = Acute Wasteload Allocation

CWLA = Chronic Wasteload Allocation

The CV value will be 0.60 unless applicable data is provided by the wastewater treatment facility. The monitoring frequency (MF) will follow the requirements noted in the departments rule, Chapter 63. However, an applicant may request increased monitoring frequency considerations in this statistical procedure. The following equations are available on Lotus 123 from the department, upon request.

DAILY MAXIMUM PERMIT LIMIT (DMPL) is derived as follows:

For $ML \geq AWLA$ $\quad DMPL = AWLA$

For $ML < AWLA$ $\quad DMPL = ML$

For $MF \leq 1$ $\quad DMPL = DAPL$

DAILY AVERAGE PERMIT LIMIT (DAPL) is derived as follows:

MIN = minimum of the AWLA or CWLA

For $AL \geq 1/1.5*MIN$ $\quad DAPL = AL$

For $AL < 1/1.5*MIN$ $\quad DAPL = 1/1.5*MIN$

Calculation equations.

ALTA = Acute Long Term Avg = exp(MU_A + H_SIG_SQ)

MU_A = LN(AWLA) - ZSIGMA

$$ZSIGMA = Z\_STATISTIC * SIGMA$$

$$SIGMA = (SIGMA\_SQ)^{0.5}$$

$$SIGMA\_SQ = LN(CV^2 + 1)$$

$$CLTA = \text{Chronic Long Term Avg} = exp(MU\_C + H\_SIG\_SQ)$$

$$MU\_C = MU4 - H\_SIG\_SQ + 0.5 * AC$$

$$MU4 = LN(CWLA) - Z95 * ABC$$

$$H\_SIG\_SQ = 0.5 * SIGMA\_SQ$$

$$AC = LN(AB)$$

$$ABC = AC^{0.5}$$

$$AB = AA/4 + 1$$

$$AA = exp(SIGMA\_SQ) - 1$$

$$ML = exp(MU\_MAX + 1.645 * SIGMA)$$

$$MIN = \text{Minimum of ALTA or CLTA}$$

$$MU\_MAX = LN(MIN) - 0.5*SIGMA\_SQ$$

CCC = 1.645 * SIGMA_MT$^{0.5}$ + MU_AVE

SIGMA_MT = LN(CC)

MU_AVE = (SIGMA_SQ - SIGMA_MT)/2 + MU_MAX

CC = AA/(34.6501 - MF) + 1

Z_STATISTIC = z_G

z_G is the value of z from the table of values of the Standard Normal Distribution Function for the value G.

G = (100 - F)/100

F = MF/(34.6501/7)

AL = exp(CCC)